metal finishing Journal

PAINT APPLICATION, ELECTRODEPOSITION, VITREOUS ENAMELLING, GALVANIZING, METAL SPRAYING and all METAL FINISHING PROCESSES.

Vol. 6 No. 63 (New Series) MARCH 1960

BEAUTIFUL COLOURS AND BRILLIANT WHITES COME FROM TIOXIDE

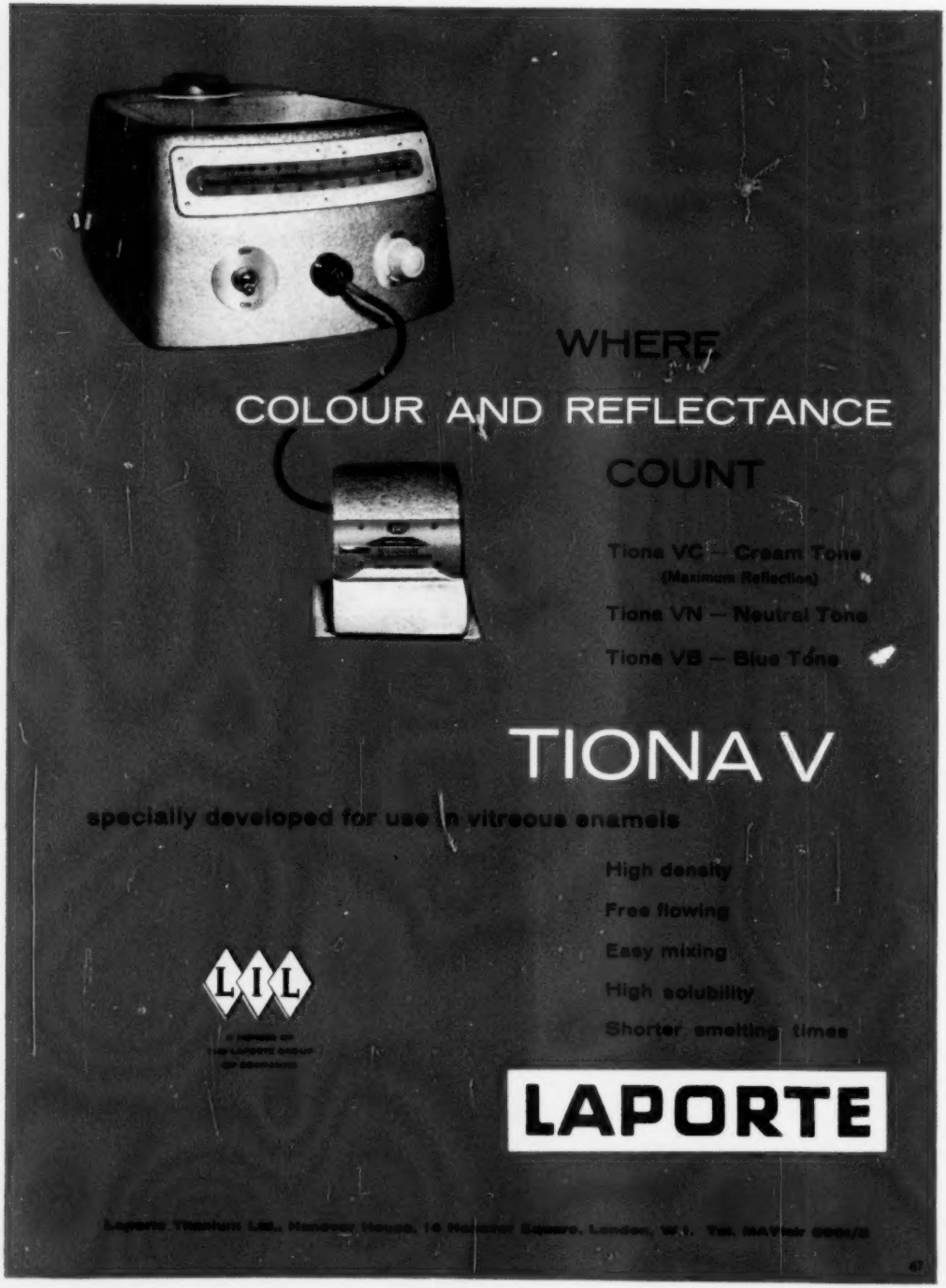
. . . the finest white pigments in the world for brightness hiding power and long life

BTP TITANIUM PIGMENTS

British Titan Products Co Ltd

10 STRATTON STREET LONDON W.1

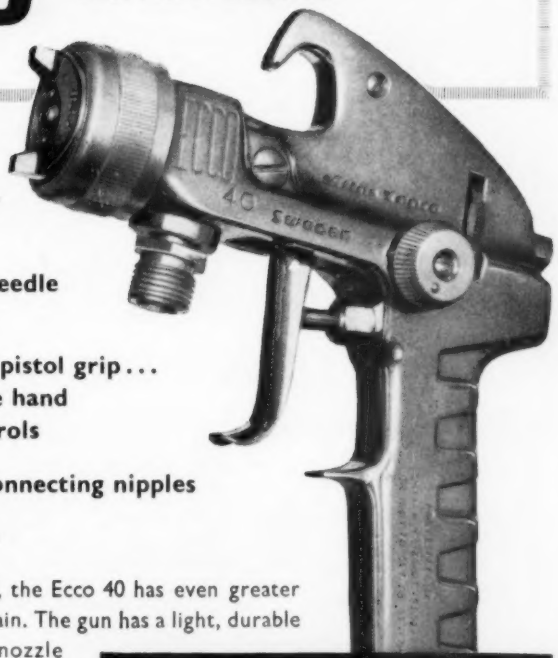
20.4A


WHERE
COLOUR AND REFLECTANCE
COUNT
Tiona VC — Cream Tone
(Maximum Reflection)
Tiona VN — Neutral Tone
Tiona VB — Blue Tone
TIONA V
specially developed for use in vitreous enamels
High density
Free flowing
Easy mixing
High solubility
Shorter smelting times
LIL
LAPORTE

INTRODUCING THE

ECCO 40

A new, even better spray-gun developed from the highly successful ECCO 30



- ✳ **Large air ducts and effective nozzle combinations for greater capacity**
- ✳ **New packing system for paint needle prevents leakage**
- ✳ **Ease of operation—comfortable pistol grip... long, two-finger trigger... single hand adjustment of fluid and fan controls**
- ✳ **Interchangeable paint and air connecting nipples**
- ✳ **Few parts simplify maintenance**

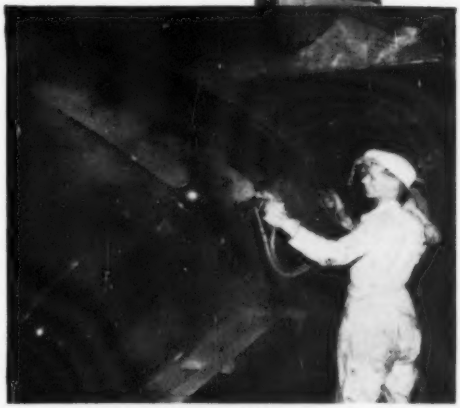
Based on the highly successful Ecco 30, the Ecco 40 has even greater capacity and is easier to operate and maintain. The gun has a light, durable body of modern design and a range of nozzle combinations enabling it to be used for all spray-painting jobs.

USED DAILY AT JAGUARS!

All over the world, the name 'Jaguar' means performance and good looks. At their Coventry works—where craftsmanship is allied to modern production methods—Jaguar Cars Ltd., have introduced Ecco 40 guns to apply the finishes for which they are famous.

A COMPLETE RANGE OF COMPRESSED AIR EQUIPMENT

Atlas Copco manufactures portable and stationary compressors, rock-drilling equipment, loaders, pneumatic tools and paint-spraying equipment. Sold and serviced by companies and agents in ninety countries throughout the world.

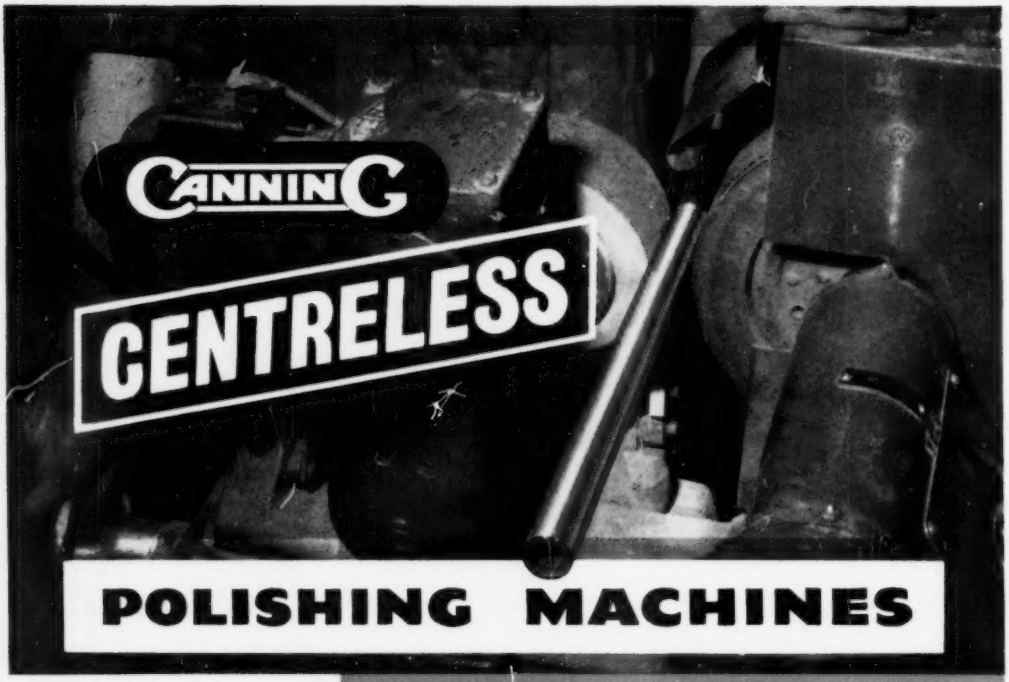


Photograph by courtesy of Jaguar Cars Ltd.

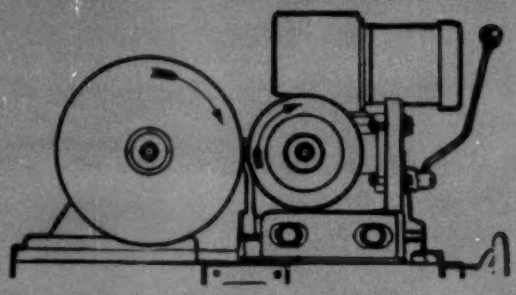
Atlas Copco PUTS COMPRESSED AIR TO WORK FOR THE WORLD

Contact your local company or agent or write to Atlas Copco AB, Stockholm 1, Sweden

B.33



FOR THE RAPID FINISHING OF TUBES, RODS AND A WIDE VARIETY OF CYLINDRICAL SHAPES.



Component is fed between the polishing mop and the feed roller.

Centreless machines save time and labour.

- ★ They give a uniform finish at low cost.
- ★ Can be operated by unskilled labour.
- ★ Have a high output capacity.
- ★ An adjustable rate of feed.
- ★ Are available in three types to suit all requirements.

Attachments are supplied to enable a wide range of circular articles to be polished.

Please ask for publication No. 1038.

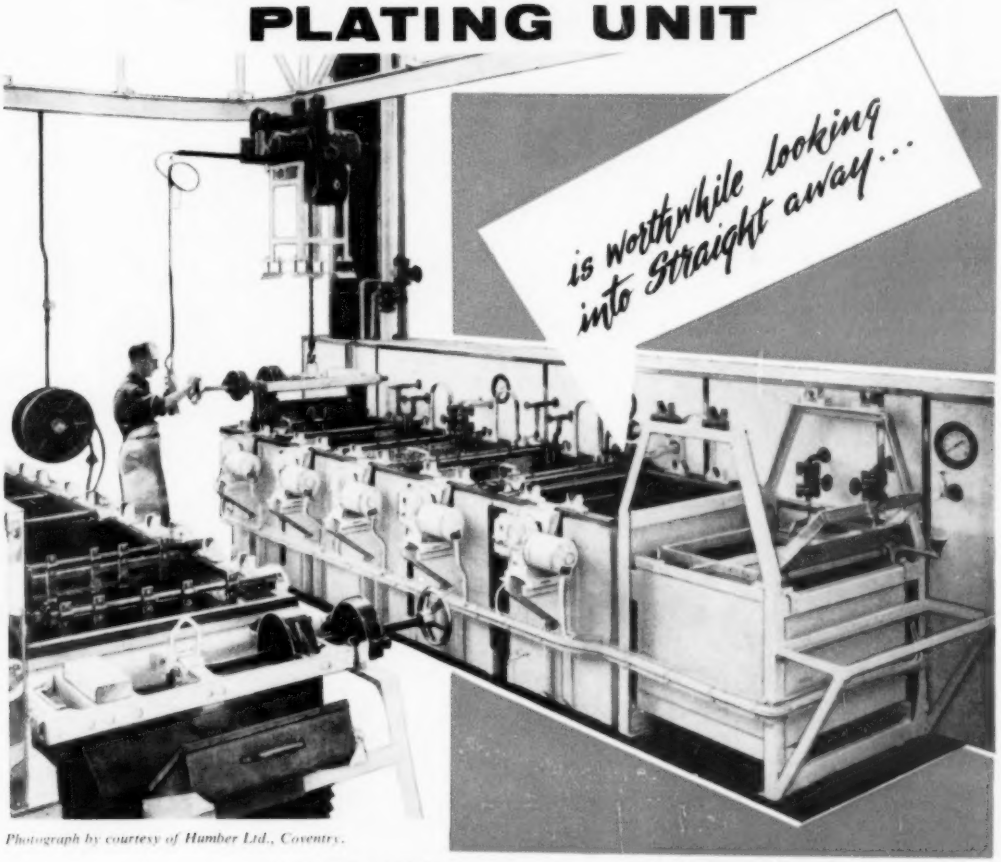
CANNING & CO. LTD. BIRMINGHAM 18. *Telephone: CEN. 8621* LONDON & SHEFFIELD

If you are interested in barrel plating a

CANNING

"SUBMATIC"

AUTOMATIC BARREL PLATING UNIT

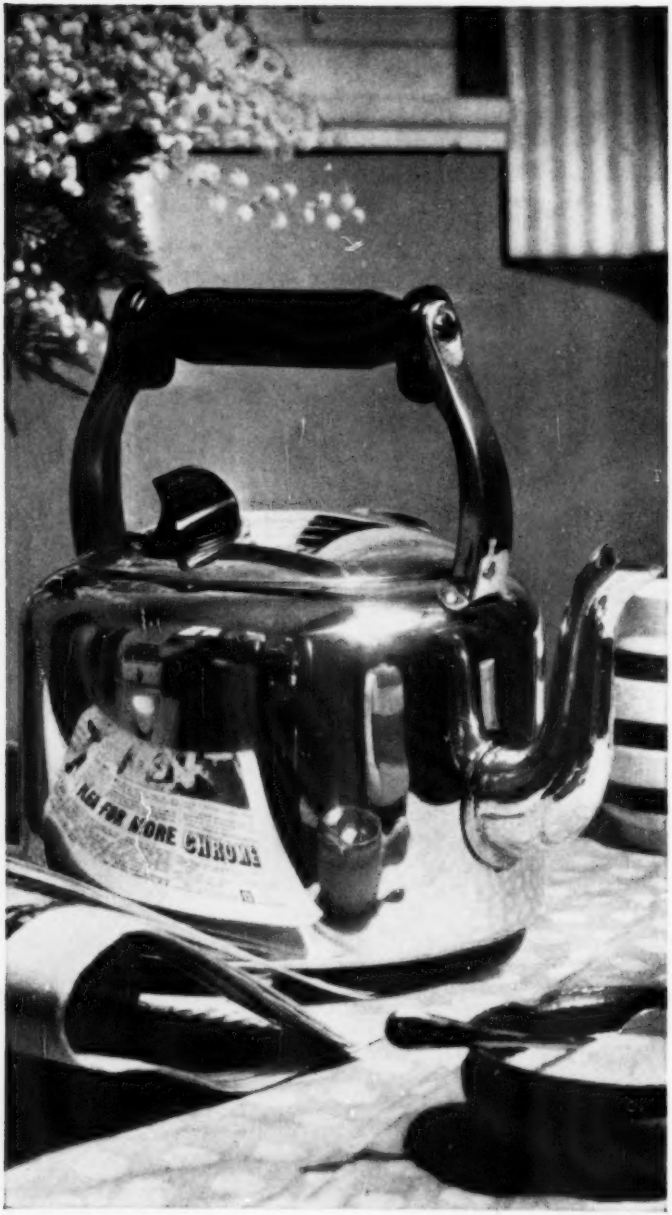


Photograph by courtesy of Humber Ltd., Coventry.

a "SUBMATIC" provides continuous output for zinc, cadmium, brass, copper and nickel plating

* **Built up from separate barrel units each with individual drive. This gives great flexibility for varying outputs as the number of barrel units making up the plant can be easily increased or decreased as required.**

CANNING & Co. Ltd. BIRMINGHAM • LONDON & SHEFFIELD



FOR
HARDEST
BRIGHTEST
FINISH

CHROME

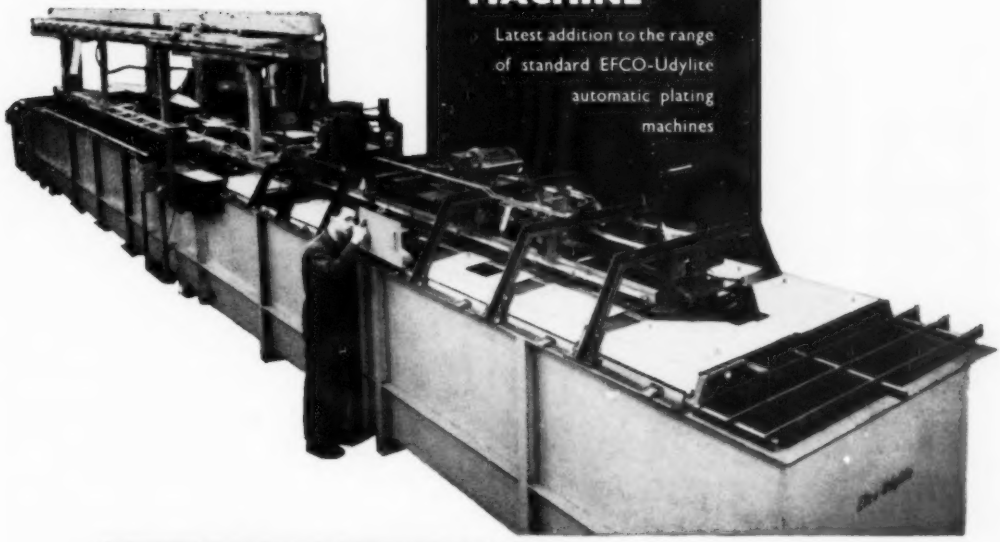
Chromic Acid
Sodium Dichromate
Potassium Dichromate
Chromic Oxide

BRITISH CHROME & CHEMICALS LIMITED
A member of the
ASSOCIATED CHEMICAL COMPANIES GROUP
Sales enquiries to
Associated Chemical Companies (Sales) Limited
P.O. BOX NO. 6, LEEDS 1. PHONE: LEEDS 29321/8. GRAMS: ASCHEM. LEEDS.

the new **U N I T** built

AUTOMATIC PLATING MACHINE

Latest addition to the range of standard EFCO-Udylite automatic plating machines



Efco-Udylite 'Cyclemaster'

A new automatic plating machine built from standard units and delivered assembled for speedy site installation. The 'Cyclemaster' processes from 40 to 100 racks hourly with maximum rack dimensions of 36" x 16" x 8".

OVER 1,000 EFCO-UDYLITE AUTOMATICS ARE IN USE

MBP 2536

EFCO **ELECTRO CHEMICAL ENGINEERING CO. LTD.**

SHEERWATER, WOKING, SURREY. Woking 5222/7

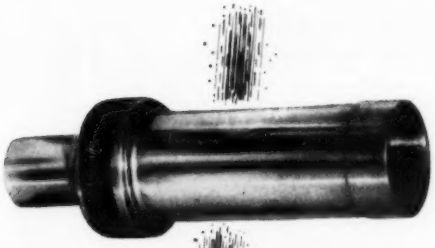
LARGE OR SMALL
CONTINUOUS
'A' TYPE OVENS FOR
METAL FINISHING

Illustrated above: A large gas fired air circulated "A" type stoving oven for both hand dipped and sprayed work, covering a wide size range and gauge of parts. Conveyor width 9' 0" with a clear hanging depth of 5' 0".

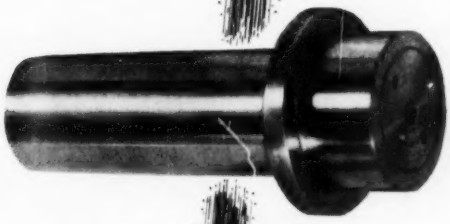
Our latest Catalogue No. 50 describes and illustrates Stordy Plant for pretreatment and metal finishing.

Illustration below: A small type "A" stoving oven, town gas fired and fully air circulated for prime and finish stoving of a large range of sheet metal and small cast components. Loading width 4' 0", hanging depth 3' 6".

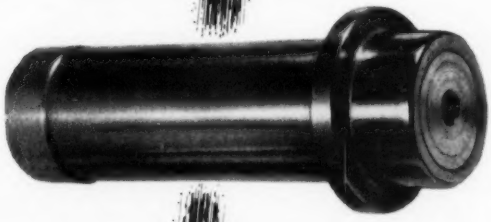
STORDY ENGINEERING LIMITED
CUMBRIA HOUSE · GOLDTHORN HILL · WOLVERHAMPTON



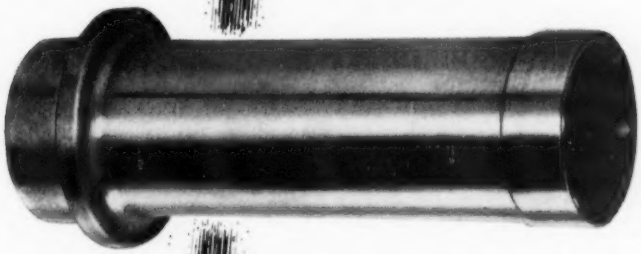
Perfection!



UNIBLAST



C.T.B NOZZLES



FOR LONGER LIFE!

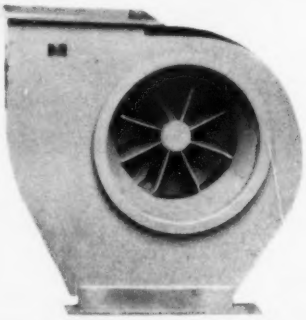
MANUFACTURED

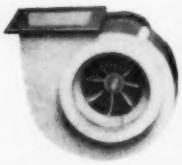
IMPREGNATED DIAMOND PRODUCTS LTD. · TUFFLEY CRESCENT · GLOUCESTER

DISTRIBUTED BY

UNIVERSAL GRINDING WHEEL COMPANY LIMITED · STAFFORD · TEL. STAFFORD 318

CHEMICAL FUME EXTRACTION PLANT IN PVC





27" DIAMETER INLET

THE FIRST AND STILL THE BEST

this is our business and we're good — VERY GOOD at our job...

THE PLASTIC FAN Co. Ltd.,

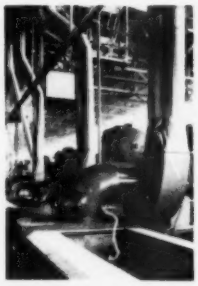
EDWARD STREET, WEST BROMWICH, STAFFS.

West Bromwich 2751

SMALL SCRUBBING UNIT

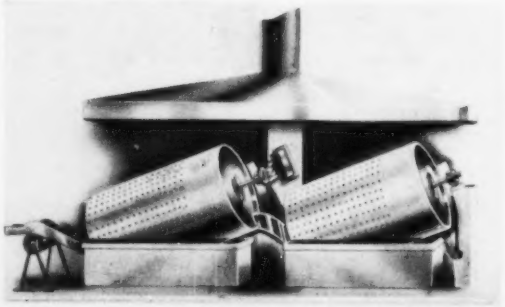
★

A PIC PLANT EXHAUST SYSTEM

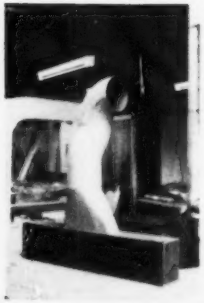


THE EFFICIENCY OF OUR PRODUCTS

- SAFEGUARDS HEALTH
- IMPROVES PRODUCTIVITY
- REDUCES COSTS



PART OF AN AUTOMATIC BARRELLING PROCESS



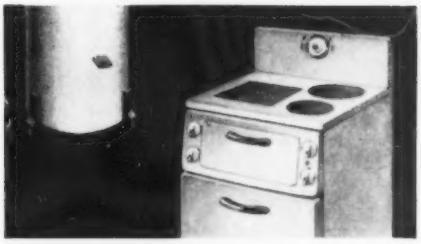
New Luxol Acrylic Stoving Finish

Almost as hard as Vitreous Enamel!

Here is a new, harder, tougher stoving finish than has ever before been available to manufacturers and processors of domestic and industrial equipment.

In terms of hardness Luxol Acrylic Stoving Finish is almost comparable to vitreous enamel, though considerably cheaper and less liable to chip during assembly. It brings a new improved standard of protection to every type of product. Colours are crisper, cleaner and possess exceptional stability; white is really white *and will not yellow with age.*

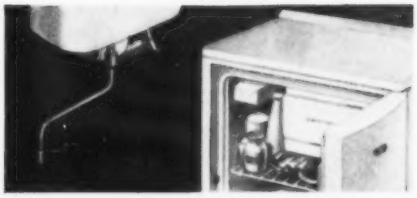
Moderate overbaking has no effect upon Acrylic colours; fewer rejects contribute still further to reducing production costs.



Perfect colour retention

Brilliant clarity of colours

Greater impact resistance



Increased durability

Luxol Acrylic Stoving Finish offers much to a great variety of products.

REFRIGERATORS—Longer, smarter life with its increased toughness plus flexibility, perfect colour retention and new colour brilliance.

WASHING MACHINES—Greater durability with superior stain and detergent resistance.

GAS AND ELECTRIC COOKERS AND WATER HEATERS, ELECTRIC IRONS—Now more efficient with a finish that is unaffected by temperatures between 350° - 400° F.

HOSPITAL, KITCHEN AND BATHROOM EQUIPMENT, METAL FURNITURE—All improved products with the ability to maintain their immaculate appearance throughout years of use.

Luxol Acrylic Stoving Finish does not interfere in any way with existing production systems.

BRITISH PAINTS LIMITED

INDUSTRIAL FINISHES DIVISION

Portland Road, Newcastle upon Tyne, 2.
Northumberland House, 303-306 High Holborn, London, W.C.1
31, Wapping, Liverpool.

Belfast · Birmingham · Bristol · Cardiff · Glasgow · Leeds · Manchester · Norwich · Plymouth · Sheffield · Southampton · Swansea and all principal towns.

NEWTON

PLATING JIGS & INSULATIONS LTD.

Quality . . .
Design . . .
Service . . .

and
guaranteed competitive prices

for
THE FINEST PLATING JIGS IN THE TRADE

13 STRAFFORD ROAD, ACTON W.3
Telephone : Acorn 6157

MIDLAND REPRESENTATIVE : D. BRADBURN
222 WESTWOOD ROAD,
SUTTON COLDFIELD, BIRMINGHAM

ELECTRO-PLATERS

A.I.D., A.R.B. & I.A. Approved

ELECTRO-PLATING—Chrome, Copper, Nickel, Cadmium, Silver, Zinc, Bright Nickel, Bronze, Tin, etc.

ANODISING—Chromic and Sulphuric Acid processes. Decorative Silver Anodising and Sealing in longest dimensions a speciality.

STOVE ENAMELLING · CELLULOSING · CHROMATING
PHOSPHATING · PASSIVATING · LACQUERING

OUR FACTORY, *equipped with a large, modern and efficient Plant, can undertake all types of Metal Finishing.*

24-HOUR SERVICE *on repetition work.*

FREE *collection and delivery.*

ROBERT STUART (LONDON) LTD.

ASCHAM STREET, KENTISH TOWN, N.W.5

Tel.: GULliver 6141 (*six lines*)

As a Plater you need this booklet

If you produce chromium plating you need to be aware of the Mond campaign to increase confidence in plating standards. It's described in detail in this illustrated booklet 'CONFIDENCE IN PLATING'. Here you'll see the press and TV advertising which will back this scheme in your interests. Right through the scheme runs the theme 'Chromium plating *can* be good!'

Your customers will want to know!

Do you supply the finished goods? Customers will be looking for the coloured labels of plating quality which are part of the Mond campaign.

Do you carry out plating for other people? Then show the special seal of plating standards on your estimates. For this entitles your customer to display the label.

Buyers of cars, household equipment, tools, furniture, and fittings of every type will be looking for plating they can be proud of. Make sure that *you*, as a plater, know all about this new campaign.

THE MOND NICKEL CO LTD

Thames House · Millbank · London · SWI

A new deal for Chromium Plate

FOR FURTHER INFORMATION ON THE LABELLING SCHEME COMPLETE AND RETURN THIS COUPON

Please send me your booklet 'CONFIDENCE IN PLATING' *with details of how I can join the scheme.*

NAME _____

ADDRESS _____

_____

COMPANY AND POSITION _____

_____

TGA P1A

'THREE ELEPHANTS' in every kitchen

. . . Three Elephant Brand Borates, of course! These pure, versatile products give stronger, finer vitreous enamel finishes and pottery glazes.
PYROBOR (Anhydrous Borax $Na_2B_4O_7$) gives very real savings in the preparation of vitreous enamel and glaze frits, because there is no waste of heat or time in driving off water of crystallization before fusion.

PYROBOR · V-BOR · BORAX · BORIC ACID
Lithium Ores · Lithium Carbonate
Lithium Hydroxide

BORAX AND CHEMICALS LTD

Subsidiary of American Potash & Chemical Corporation
Producers of: Borax, Soda Ash, Salt Cake, Lithium, Bromine, Chlorates, Perchlorates, Manganese Dioxide and a diversified line of Agricultural and Refrigerant chemicals.

35 Piccadilly, London, W.1. *Telephone:* REGent 2751 *Cables: Boraxchem, London.* BAC/14A

Over 1 million A.D. Taccy Rags produced in 1959

NOW—A TEST-TUBE TACK-RAG

FORMULATED TO KEEP PACE WITH MODERN PAINT TECHNOLOGY!

★ Formulated for economy and efficiency
★ Completely free of solvent residues
★ Completely unaffected by ageing or prolonged exposure
★ Widely compatible with modern surface coatings
★ Neutral constituents - no danger of acid attack on susceptible metals.

NEW PAINTER'S TACCY DUSTER

The only tack-rag with ORIGINAL research behind it!

ANTI-DUST SERVICES LTD. P.O. Box 28, Dudley. Tel. 54816
London : 27 Eastern Avenue, E.11. WAN. 3467

NEW! **'TRISEC'**

for stain-free metal drying

'Trisec' Metal Drying Assistant is a new product of I.C.I. for use in modified I.C.I. degreasing plants. 'Trisec' is ideal for the rapid drying of metal after aqueous processes, such as electroplating, electropolishing, phosphating, chromating, contour etching, pickling, alkaline de-rusting, etc. 'Trisec' is used as an additive to trichloroethylene (1 part to 80) to displace water from metal articles, leaving them completely stain-free. Hot rinses, hot air ovens, wiping and sawdust barrelling are therefore eliminated by using 'Trisec' Metal Drying Assistant.

'TRISEC'
metal drying assistant

ICI

For literature and other details write to:

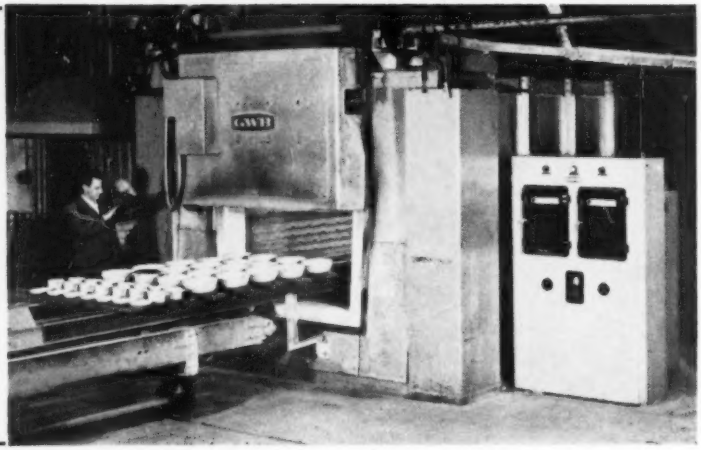
IMPERIAL CHEMICAL INDUSTRIES LIMITED LONDON S.W.1

DP.260

G.W.B. Enamelling Furnace

CUTS HANDLING AND REJECT COSTS

Elements and refractories have 10 year life



The demand for high-quality finish and brightness in a wide colour range, plus the necessity to obtain the most economic working life from production equipment, has recently led Izons and Co. Ltd. to instal a new G.W.B. electric vitreous enamelling furnace. The furnace, which has internal dimensions of 9 ft. long, 4 ft. wide and 2 ft. high, has a normal operating temperature range of 600-900° C, with a maximum of 1,000° C, is designed for long periods of continuous operation.

High-grade refractories line the heating chamber, which is built of specially moulded element-bricks supporting 80/20 nickel-chromium wire heating elements. These are located in the walls, roof and on the inner face of the door in order to stabilize chamber temperature rapidly after charging or discharging the furnace. The charging machine, which has been in use with an earlier fuel-fired furnace, has been incorporated in the design of the new G.W.B. furnace.

A COMPARISON

A comparative economy and efficiency of the old fuel-fired furnace and the new G.W.B. electric unit is worth examining. In an electrically heated unit there are no products of combustion. In a fuel-fired furnace, even with a built-in muffle which is inevitably semi-permeable, contamination is virtually impossible to avoid. As the combustion chamber is situated beneath the hearth of the chamber, the refractories suffer and frequent rebuilding is necessary. A G.W.B. electric furnace, however, has an exceedingly long life. An installation of similar type installed in 1933 *required its first replacement bricks and some new heating elements in 1942*—a very impressive absence of re-lining and "lost production" costs! In addition, the absence of flame action and the smaller temperature gradient of G.W.B. electric furnaces contribute to this longevity. Thus, after being switched off at 6 p.m. the overnight temperature loss (with a working temperature of 760° C) is 100° C. After the weekend the temperature has dropped to 540-550° C.

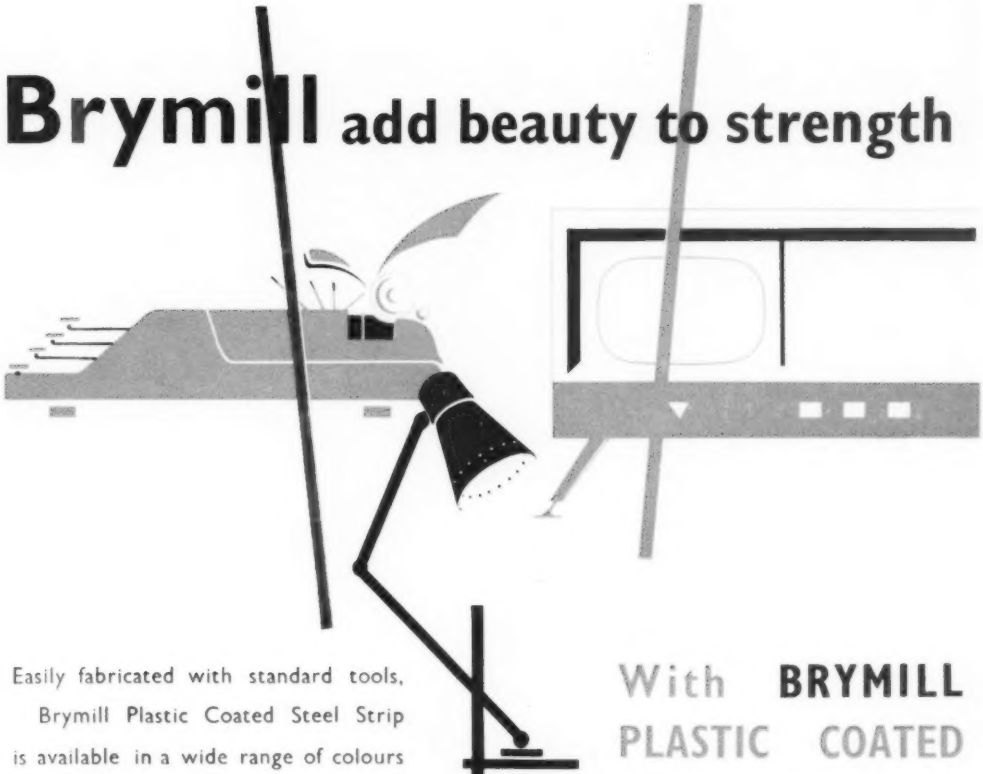
During the week the furnace is switched on again at 7 a.m. and reaches working temperature in 40 minutes. After the weekend the required temperature is reached in 2 hours. Such switching can be controlled by automatic time switches, and the furnace requires no overnight attendance. The fuel-fired furnace, on the other hand did require overnight *and* weekend attendance; a desired increase in temperature was difficult to judge and, since there was no form of steady control, it was difficult to maintain any sort of even temperature.

COST OF POWER

While electricity is more expensive in terms of B.Th.U. economies are obtained by the high quality of the product—few rejects—and the remarkably lower cost of handling and maintenance. A G.W.B. electric furnace, because it operates from a 3-phase supply, improves the power/load factors of the supply to the factory, thus reducing the cost of electricity consumed generally.

GWB **G.W.B. FURNACES LTD** · P.O. BOX 4 · DIBDALE WORKS · DUDLEY · WORCS
Telephone: Dudley 55455 (9 lines)
Associated with Gibbons Bros. Ltd. and Wild-Barfield Electric Furnaces Ltd.
G.W.B. 249

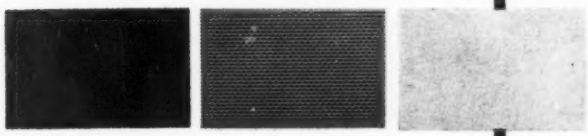
Brymill add beauty to strength



Easily fabricated with standard tools, Brymill Plastic Coated Steel Strip is available in a wide range of colours and textures and its practical application ranges from domestic products to sub-assemblies in automobiles, shipping and railways.

ENQUIRIES WILL RECEIVE OUR PROMPT ATTENTION

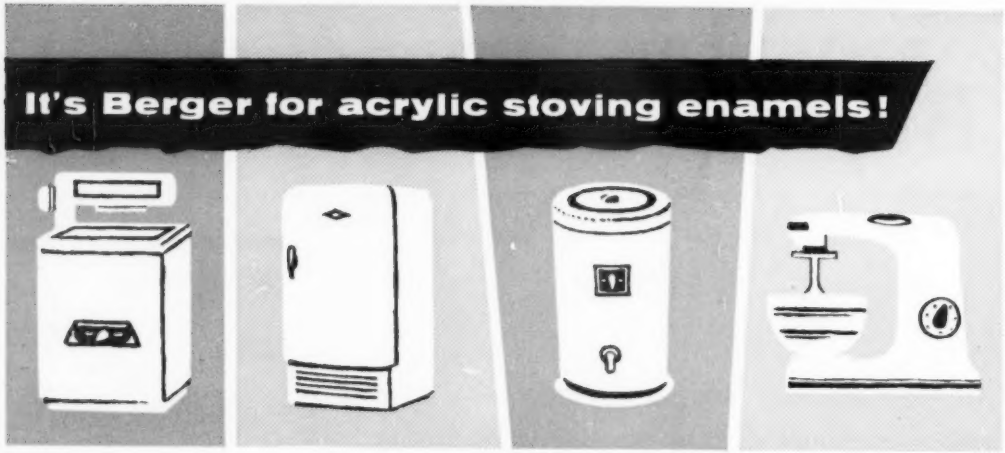
A TEXTURE OR COLOUR TO SUIT ANY PRODUCT



With **BRYMILL** PLASTIC COATED STEEL STRIP

BRITISH ROLLING MILLS LTD.

BRYMILL STEEL WORKS · TIPTON · STAFFS



A considerable technological advance now comes to British industry

BERGERCRON

one-coat finish is here!

✳ PRODUCTION LINE PLUS POINTS

ONE-COAT BERGERCRON cuts finishing costs and gives a better finish than conventional two-coat systems. It will increase production from existing plant — with fewer rejects because of its exceptional hardness.

✳ PRODUCT FINISH PLUS POINTS

ONE-COAT BERGERCRON has excellent flexibility, gloss and colour retention — white stays white. It is exceptionally resistant to detergents, grease and food staining — superior to all conventional finishes.

NOTE THESE SPECIAL BERGERCRON ADVANTAGES

Detergent resistance — 48 hours in 2½% solution at 160°F.	Outstanding
Humidity — 1000 hours at 100°F and 95% R.H.	No effect
Hot fat resistance — total immersion for 16 hours at 120°F in lard oleic mixture.	Excellent
Overstoving and double stoving.	Exceptional colour stability

Berger Paints

Quality famous since 1760

Bergercron applied direct to pretreated metal.
Photograph of test panel showing bend test and 1 mm. cross hatch at hardness 5H.

POST THIS COUPON NOW!

To:

Berger Metal Re-finishes Division, Lewis Berger (Gt. Britain) Ltd., Chadwell Heath, Essex.

Please send me more information about Bergercron.

Name .....

Company .....

Address .....

.....

metal finishing Journal

March, 1960 AN INDUSTRIAL NEWSPAPERS PUBLICATION Vol. 6, No. 63 (New Series)

Editor : JOHN HOOPER
Assistant Editor : E. H. LLOYD, A.I.M., A.C.T.(Birm.)
Southern Area Manager : E. COLLIS
Northern Area Manager : G. P. ELLIOTT
Scottish Area Manager : T. H. SMITH
Midlands Area Manager : E. J. SWEETING
Production Manager : R. J. LOVELL
Circulation Manager : E. T. GRIFFITHS
Publisher : H. J. DWYER

Official Organ of the

INSTITUTE OF VITREOUS ENAMELLERS

President :
W. T. WREN

Chairman :
J. NICHOLLS

Secretary :
J. D. GARDOM
John Gardom & Co., Ripley Derby
Telephone : Ripley 136

Published on the 15th day of each month by

INDUSTRIAL NEWSPAPERS LIMITED

Directors:—
Barrington Hooper, C.B.E., *Chairman and Joint Managing Director*
F. Barrington Hooper, *Joint Managing Director*
F. R. Lewis
John Hooper
D. Horn
E. G. Weston, *Secretary*

JOHN ADAM HOUSE
17-19 JOHN ADAM STREET
ADELPHI, LONDON, W.C.2
Telephone : TRAfalgar 6171 (P.B.X.)
Telegrams : Zacatecas, Rand, London

Subscription Terms :
Home and Overseas 24*s.* per annum prepayable
Single copies 2*s.* (2*s.* 4*d.* *post free*)

THIS JOURNAL IS DEVOTED TO THE SCIENCE AND TECHNOLOGY OF PAINT APPLICATION, ELECTRODEPOSITION, VITREOUS ENAMELLING, GALVANIZING, ANODIZING, METAL SPRAYING & ALL METAL FINISHING PROCESSES. THE EDITOR IS PREPARED TO CONSIDER FOR PUBLICATION ANY ARTICLE COMING WITHIN THE PURVIEW OF "METAL FINISHING JOURNAL" AND ALL SUCH ARTICLES ACCEPTED WILL BE PAID FOR AT THE USUAL RATES.

Contents

PAGE

"Identification Parade" **85**

Talking Points **86**
"Platelayer"

An Investigation into the Effect of Detergents on Vitreous Enamel—A Technical Sub-Committee Report of the Institute of Vitreous Enamellers **87**

Problems of High-temperature Corrosion in Modern Process Plants **95**
John I. B. Rutherford

Finishing Post **102**
Some comments by Dr. T. P. Hoar on the Corrosion Science Society

Continuous Oxidation of Aluminium Foil for Electrolytic Condensers Using Alternating Current **103**
B. M. Tareev and M. M. Lerner

Crack-free Chromium Plating **109**
J. Corbière

Finishing News Review **113**

Plant, Processes and Equipment **123**

I.C.I. Titanium rack used by Hoover (Washing Machines) Ltd. for processing components through chemical brightening and anodising solutions. Experience to date indicates a maintenance-free service life of at least 2 years (2,500 cycles), compared with an average life of less than 3 weeks for racks in conventional materials.

Operations simplified and costs substantially reduced—these are the proved results of using I.C.I. Titanium for anodising jigs. Titanium jigs need no stripping or cleaning between anodising cycles. They offer complete reliability throughout months—even years—of service. This revolutionary development means a big reduction in maintenance and replacement costs: fewer operations in each cycle, resulting in faster throughput: and a marked drop in rejections due to imperfect stripping or damaged tips.

Titanium *slashes anodising costs*

Titanium is still a relatively expensive metal, but its use in this application is abundantly justified, since the higher initial cost of titanium jigs will be recovered in 3 - 6 months' service.

Full details in our leaflet

'I.C.I. TITANIUM FOR ANODISING JIGS'

I.C.I. TITANIUM

IMPERIAL CHEMICAL INDUSTRIES LIMITED, LONDON S.W.1

TM39

ICI METALS DIVISION

IDENTIFICATION PARADE

NOT so very many years ago the intending purchaser of, say, a wheelbarrow, had very little scope for exercising his freedom of choice, as all the models available were made of wood with an iron-tyred wheel and varied very little in style between the products of one manufacturer and another. Today the position is vastly different and more complex. In addition to the traditional wooden wheelbarrow there are now wheelbarrows fabricated from galvanized sheet steel, from high density polythene and from glass-fibre-reinforced polyester resins. Wheelbarrows now have one or more rubber-tyred wheels and can be adapted for performing such tedious chores as distributing weed killers and fertilisers.

The enthusiastic gardener undoubtedly revels in this greatly extended field of choice and provided that he has the opportunity to study the claims and properties of rival models, he will enjoy the process of finally selecting that one which most nearly conforms with his individual requirements. While this may be true however, in relation to an informed purchaser such as a gardener, for example, very different conditions may obtain in relation to the purchase of materials and wares in other categories.

When our gardener, for example, visits his tailor with a view to buying a new suit, what criteria are available to him to guide him in exercising his choice between a cloth based on polyacrylonitrile fibres as against one containing polyethyleneterephthalate ? Indeed, if he is a regular traveller on the London Underground he will probably be readily conditioned to believe that " there is no substitute for wool." The results of chemical research in recent years, and indeed of research in other fields as well as chemistry, have placed at the disposal of the manufacturer a very much wider range of materials from which he can choose for the construction, protection, or decoration of his product.

In this embarrassment of choice some guidance must clearly be given and there has been evident recently a growing appreciation of the need for it, particularly insofar as the ultimate consumer is concerned. To a housewife faced with an array of nickel/chromium plated articles one bright shiny surface looks very much like another and she is certainly not equipped to carry out rapid thickness determination of the coating on the spot, still less to subject her projected purchase to an accelerated corrosion test. Similarly the glossy white or coloured surface on a refrigerator, cooker or washing machine in its pristine freshness in the showroom, provides few clues as to how well it may be adapted to withstand the use and abuse which it will encounter in the kitchen.

The latest move to help the housewife to arrive at a decision in this respect has been the introduction of identification labels. The Mond Scheme for identifying nickel/chromium plate has been referred to before on this page and we are glad to hear of its growing impetus. Now comes news, reported elsewhere in this issue, of a new label to be affixed to vitreous enamelled surfaces in order to distinguish them from organic coatings which may appear virtually identical on superficial examination. This is a developing trend which must be welcomed. Correct decisions can be made only on the basis of availability of adequate information. It is the responsibility of the supplier of every material, process or product to ensure that adequate factual information is available to guide the potential purchaser in making his choice.

Talking Points

by "PLATELAYER"

TOPICAL COMMENT FROM THE MAIN LINES AND SIDE LINES OF METAL FINISHING

A NEW WAY WITH CHROMIUM

A NEW method of vapour plating chromium, which is still in the development stage, has been announced in the U.S.A. It depends on the use of a group of liquid organo-chromium compounds described as "di-arenes." Their structure consists of a "sandwich" of a chromium atom between two substituted hexagon ring compounds such as benzene, toluene or cumene. The compounds contain some 30 per cent of chromium as metal and on heating them with the article to be plated (which need not be metallic) to temperatures above 300°C, a thin, highly adherent, uniform coating of bright chromium is deposited. The cost is anticipated to be low.

However, as usual there are snags. The di-arenes are not only very toxic, but they are also readily oxidized. They must, therefore, be stored under an inert gas, and the plating operation must also be carried out in an atmosphere of nitrogen.

The process may find application for special purposes, but it does not seem likely that it will prove to be a substitute for chromium plating.

PRIZE-WINNER

TWO years ago an enterprising young Coventry engineer won a televised newspaper competition in which he was awarded a sum of money to start a plating business with the object of meeting the needs of the electronics industry for precision plated precious metals.

In the short time that has elapsed, the business has become a very successful one indeed, with numerous satisfied customers. The fact is that there is a real demand for specialized electrodeposition where price is secondary to accuracy and quality. While the average plating firm is always trying to get large outputs of work which present the minimum of problems, it may well be that the really difficult plating jobs which other people are unwilling to tackle may prove to be a much less competitive field, and more remunerative to boot, as well as more interesting. There is still considerable scope in electroplating for anyone with imagination, and it is pleasing to find that it is occasionally possible to win a prize on television by means of ideas. The most usual way to fame and fortune seems to be by some such activity as dragging one's wife through a row of hoops backwards in the shortest possible time !

HOW MANY STUDENTS ?

IT has become commonplace to read dismal comments in the press about the relatively small number of university graduates being produced in this country. Out of 27 major countries only three, Ireland, Turkey and Norway, have fewer students per million than Britain ; Russia and the United States have almost ten times as many. It is planned to increase our university population from the present figure of 100,000 by 50 per cent. over the next ten years, but this will still leave us far behind.

Whether the situation is, indeed, so depressing as is made out, depends on whether one can fairly assume that the number of university students a country has is a measure of its progressiveness. Perhaps quality is more important than quantity, and our standards are high. And may not the skill of our craftsmen and technicians and the generally high calibre of those engaged in what may be termed the less academic aspects of industry, compensate to some extent for the deficiency of graduate numbers ?

So far there is no real evidence that we are at a disadvantage as compared with countries having much larger student populations, but the argument is that the discrepancy will make itself felt in the years to come.

Time alone will tell, but let us not assume that university men and women have a monopoly of brains, intelligence and initiative. After all, a recent survey of the background of Americans who have reached high positions in the business world showed that academic distinction is a positive disadvantage in this field !

MULTIPLICATION BY DIVISION

IT seems that a Cathodic Protection Panel of the Corrosion Group of the Society of Chemical Industry is likely to be established to arrange meetings and discussions on this subject.

Sub-divisions of technical societies are commonplace, but sub-divisions of divisions are still relatively new. Like the amoeba, technical bodies are beginning to multiply by division !

Furthermore I now hear of the formation of a new organization to be called the Corrosion Science Society.* The name is different, but the people concerned will, in all probability, be exactly the same. Fortunately, or unfortunately, there will continue to be enough corrosion to go round.

(* An appreciation of the objectives of the Corrosion Science Society is the subject of a letter from Dr. T. P. Hoar published in page 102 of this issue. Ed.)

An Investigation into

THE EFFECT OF DETERGENTS ON VITREOUS ENAMEL

A Technical Sub-Committe Report of THE INSTITUTE OF VITREOUS ENAMELLERS

Sub-Committee

Mr. N. S. C. Millar (Radiation Ltd.) Chairman and Convenor.
Mr. G. R. Ball (Borax Consolidated Ltd.)
Mr. J. A. Clarke (Bilston Foundries Ltd.)
Mr. G. A. Greenwell (Metal Porcelains Ltd.)
Mr. E. Lawrence (Escol Products Ltd.)
Mr. A. W. Murdoch (Ferro Enamels Ltd.)
Mr. R. C. Stilton (Albright & Wilson Ltd.)

Summary

THE Sub-Committee have proposed a simple method for testing the detergent resistance of enamels whereby a numerical grading is allocated to the finish. Variations in testing procedure are described.

Several types of enamel were exposed to a series of commercially available detergents and also to sodium carbonate solution and the resultant attack was noted. Using the recommended method of test, the active ingredients in detergents and also the influence of several modifications to the enamel milling were examined.

Introduction

In recent years the growing use of synthetic detergents in several cleansing operations has necessitated the formulation of special vitreous enamels, designed to withstand the peculiar attack of this class of chemicals. It soon became evident that, although an enamel may pass the BS.1344 alkali-resistance test, it was not necessarily resistant to the several detergents used in present-day washing machines. The technical literature contained meagre information on this subject and it was consequently decided to inaugurate a Sub-Committee of the I.V.E. Technical Committee to " Devise a method of test and to examine the effect of detergents on vitreous enamel."

Preliminary Investigation

0.5 per cent solutions in distilled water of nine commercial detergents were prepared and heated to 98 to 100°C. in beakers. Test strips of enamelled iron and steel were half immersed in the various solutions for increasing periods of time and examined at half-hourly intervals for any visible sign of attack. Immediately before examination each panel was rubbed to remove any surface deposit, then dried. The cast-iron plaques were preheated to 100°C. before immersion in the test solutions. A control using 5 per cent anhydrous sodium-carbonate solution was also carried out.

For this programme of work " detergents " were taken to mean any cleaning material containing a surface-active agent and used as an aqueous solution, this including soap alone but excluding abrasive cleaners.

Eight types of sheet-iron enamel and four cast-iron enamels were evaluated, duplicate tests being made in each case.

The *p*H of the ten solutions was measured using a Cambridge direct-reading *p*H meter (calomel half cell in conjunction with a glass electrode).

Solutions	pH at 20° C.
Tide	10.1
Dreft	9.2
Daz	10.1
Surf	9.8
Omo	9.9
Fab	9.75
Stergene	6.9
Persil	10.7
Quix	8.3
Sodium Carbonate	11.0

Enamels

Sheet Iron

I. Acid-resisting antimony oxide white.
II. Acid-resisting titania superopaque white.
III. Acid-resisting titania semi-opaque white.
IV. $Al_2O_3/B_2O_3/P_2O_5$ based white.
V. Non-A.R. sign red.
VI. Reputedly alkali-resisting white.
VII. Acid-resisting grey self mottle.
VIII. Acid-resisting groundcoat.

Cast Iron

A. Non-A.R. antimony oxide opacified bath white.
B. Acid-resisting antimony white—wet process.

C. Acid-resisting clear — wet process.
D. Acid-resisting black.

Each frit was milled, applied and fired, under the optimum conditions required in each case.

Table I. Results and Conclusions.

Detergent	Sheet Iron								Cast Iron			
	Most Resistant				Least Resistant				Most		Least	
Tide	VI	IV	III	VIII	VII	II	I	V	C	B	D	A
Dreft	VI	II	VII	III	I	VIII	V	IV	B	D	C	A
Daz	VI	III	VII	I	IV	VIII	II	V	D	B	C	A
Surf	I	IV	VII	VI	VIII	III	II	V	C	B	D	A
Omo	I	VI	III	VII	VIII	II	IV	V	B	C	D	A
Fab	IV	VIII	III	I	II	VI	VII	V	B	D	C	A
Stergene	III	II	VI	I	VII	VIII	V	IV	B	C	D	A
Persil	VI	III	II	VII	I	VIII	V	IV	D	C	B	A
Quix	I	II	IV	VII	VI	III	VIII	V	D	C	B	A
5% Na_2CO_3	VII	V	III	II	VII	VI	I	IV	D	C	B	A

Results and Conclusions

1. From these results it is apparent that the different detergents have varying effects on the several types of enamel.

2. The order of resistance of these enamels to sodium carbonate differs from that obtained with the detergents.

3. The soft sign enamel and the alumino-borophosphate based enamels used are particularly vulnerable to the majority of reagents used.

4. The semi-opaque A.R. titania enamel and the alkali-resistant finish generally had the best resistance.

5. Of the cast-iron enamels, the three A.R. finishes were consistently more resistant than the dry process antimony-opacified bath white.

6. It was not possible to grade the detergents into any order of potency as this varied with the various enamels. Stergene and Quix were the two least corrosive.

7. It was observed that a scum formed on the enamel surface during attack, which in the early stages, could be removed completely by abrading with finely powdered frit or a " typewriter rubber," leaving an apparently unattacked finish. After more prolonged exposure to detergent it was not possible to restore the original gloss by such abrasion indicating that, while the surface deposit had been removed, the underlying enamel had been attacked.

8. The first area to show any sign of attack was at the liquid/air interface.

9. There was some loss of gloss above the liquid/air interface, suggesting that some splashing had occurred or else the vapour had a corrosive effect.

From these conclusions it is apparent that the first requirement is a satisfactory method of test which can be used to explore the action of detergents on enamel. To this end, several washing machine manufacturers were approached, requesting details of their test methods. Replies indicated that in the majority of cases an empirical method was employed, *e.g.* boiling a dilute detergent solution with clothes in an actual appliance and noting the loss of gloss after a period of time. One company used a more scientific method based on the P.E.I. test. This was to immerse an enamelled test panel in a 1 per cent sodium pyrophosphate solution, maintained at 190°F. $\pm$ 5° for a length of time, then dry and measure the weight loss at two hourly intervals.

From these replies it was thought that none of the tests used were completely satisfactory and that a new one should be devised which would be simple and cheap to operate, be as representative as possible for any type of detergent and also grade enamels according to their detergent resistance.

Test Apparatus

It was decided to evaluate the action of a 1 per cent solution of "Dreft" in distilled water on triplicate sets of a superopaque titania sheet-iron enamel and also an A.R. groundcoat by several methods. A bath enamel was also examined. The temperature of test was " almost boiling." Before examination, half of each panel was rubbed to remove surface deposit. The methods evaluated were as follows :—

(a) Test solution in glass tube clamped to test panel and heated by immersion heater (*cf* BS. 1344 alkali resistance test).
(b) Half immersion of test panel in solution contained in open beaker.
(c) As (b) but employing a conical flask in place of the beaker.
(d) As (b) but employing a round bottom flask.
(e) Employing flask fitted with reflux condenser.
(f) The effect of employing watch or clock glasses or inverted glass filter funnels to reduce evaporation losses was examined.
(g) The beakers and flasks were heated by sitting in or on a water bath.
(h) The method of maintaining test panels in the solution varied from resting against beaker walls to hanging from wire in mouth of flask to insertion into slots cut into a rubber bung which was inserted in the neck of the container.

Results

Good agreement was obtained between all investigators whichever method of test was employed. Work carried out at a later date indicated the desirability of maintaining the temperature of test at 96 $\pm$ 1°C.

It was decided that, as no apparent advantage resulted from the use of the immersion heater technique, this method should be abandoned in favour of the cheaper and simpler method of half immersing the panels into the solution in a glass vessel. Some method of preventing excessive

Table II

Immersion Time	A. R. Superopaque	A. R. Groundcoat
½ hour	0.0006 gm.	0.0016 gm.
1 ,,	0.0025 ,,	0.0035 ,,
2 ,,	0.0082 ,,	0.0085 ,,
4 ,,	0.0144 ,,	0.0144 ,,
8 ,,	0.0308 ,,	0.0212 ,,
16 ,,	0.0821 ,,	0.0378 ,,

evaporation losses is also recommended. The container should be any suitable boro-silicate chemical resisting glass vessel.

Evaluation of Attack

In addition to evaluating attack by visual loss of gloss, a weight loss method was also examined—this appertaining to the two sheet iron enamels.

These results refer to the average of three panels (4 in. x 1 in.). The visual assessment for the superopaque, *i.e.* time to initial loss of gloss, was one hour whereas the A.R. ground-coat showed signs of gloss reduction after 1½ hours. However, at 1 and 2 hours the superopaque had a lower weight loss than the visually superior A.R. ground-coat. After 8 hours immersion the weight loss figures agreed with the visual results but after this length of time risk of erroneous results due to enamel chipping and shaling from the edges becomes considerable.

A further method examined for evaluating detergent attack was by means of the P.E.I. pencil test for acid resistance. This method is to draw an HB pencil over the dried panel so as to mark the area which has been immersed in detergent solution and also that which was above liquid level. The pencilled enamel panel is then rubbed with a dry cloth. If more pencil mark is retained on the erstwhile submerged portion than the untreated area the surface is deemed to have failed the dry rubbing test. This is then repeated, using a wet cloth in place of the previous dry one, and again the enamel surface passes or fails the wet rubbing test.

In the cases examined it was not found possible to incorporate this method of assessment for detergent resistance due to lack of correlation with visual assessment of loss of gloss. The dry rubbing test was extremely sensitive and indicated change in the enamel surface, sometimes before it was visible. Conflicting results were obtained between the several investigators when assessing the wet rubbing test.

Effect of Active Ingredients in Detergents

In order to propose a standard solution for use in a detergent-resistance test, it is necessary to examine the effect on enamels of the active ingredients in several general detergents.

Using an antimony oxide opacified bath enamel, the following solutions, in distilled water, were examined :—

Distilled water.
0.1 per cent Lux Flakes.
0.1 per cent Lux Flakes + 0.1 per cent anhydrous sodium carbonate.
0.1 per cent Lux Flakes + 0.1 per cent domestic Calgon.
0.1 per cent Lux Flakes + 0.1 per cent sodium sesquicarbonate.

Triplicate sets of enamelled plaques preheated to 98°C. were half immersed in the solutions maintained at 98°C. in Pyrex beakers then examined at 15-minute intervals. The solutions were also renewed every 15 minutes.

Results

The most corrosive of these solutions was Lux plus Calgon, while the distilled water control had least effect, although even this did cause some loss of gloss.

* * *

Using triplicate sets of an A.R. superopaque titania enamel and an A.R. groundcoat, both applied to 4 in. x 1 in. sheet-iron strips, the following solutions were evaluated. As before, the test strips were half immersed in the solutions at 98°C. and the panels examined at half hourly intervals. The solutions were also renewed each half hour to eliminate the risk of decomposition of any ingredient during the test. Half of each panel was rubbed with finely ground frit to remove deposit and then the rubbed and unrubbed portions were examined for visible attack :—

Distilled water.
¼ per cent Lux Flakes.
¼ per cent Sylvan Flakes.
¼ per cent solution of 70/30 Lux/anhydrous sodium carbonate.
¼ per cent Lux + 0.1 per cent Calgon.
¼ per cent Sylvan + 0.1 per cent Calgon.
¾ per cent Teepol (equivalent to ¼ per cent of active ingredient).
¼ per cent Stergene.
¼ per cent composite mixture of palm oil soap, soda ash, sodium, perborate and sodium tripolyphosphate.
¼ per cent liquid anionic detergent—potassium salt.
¼ per cent built synthetic heavy duty detergent.
¼ per cent built synthetic light duty detergent.

Results

1. Good correlation was obtained between the several investigators using the distilled water standard.

2. The least corrosive of the several solutions were Stergene and Teepol, followed by Lux and Sylvan Flakes.

3. The addition of Calgon and sodium carbonate increased the corrosiveness.

4. The most corrosive was the composite mixture of soap, alkali, perborate and polyphosphate.

5. Similar results were obtained with the titania superopaque enamel and also the A.R. groundcoat.

6. In all cases the attack was found to be progressive with increasing time of immersion.

It was agreed that for a test method the solution should be at least as corrosive as any detergent likely to be encountered in actual use. A reagent equal to the most corrosive found in this series was formulated from reproducible and controllable chemicals, and is as follows :—

Anhydrous sodium carbonate	40 per cent
Tetrasodium pyrophosphate	20 per cent
*Sodium dodecyl benzene sulphonate	16 per cent
*Sodium sulphate	24 per cent

After intimate mixing this is to be used as a ¼ per cent solution in distilled water.

Method of Test — (Suggested Standard Procedure)

Suitable panels are prepared, in triplicate, of the enamels under test.

The Solution

Sodium carbonate	40 per cent
Tetrasodium pyrophosphate	20 per cent
Sodium sulphate	24 per cent
Sodium dodecyl benzene sulphonate	16 per cent

A ¼ per cent solution in distilled water of the above is prepared and sufficient poured into a container made of suitable borosilicate chemical-resisting glass, fitted with a condenser, watch glass or any other convenient means of reducing evaporation. This is heated to 96° ± 1°C. The enamelled panels, preheated if necessary, are half immersed in the solution. At half-hourly intervals the panels are withdrawn then dried and rubbed with finely powdered frit. The panels are then examined for any sign of attack over an area of uniform thickness, ignoring the liquid/air interface and also the edges of the panels. Fresh solutions are used after each examination. The length of time in hours to cause initial loss of gloss is a numerical measure of detergent resistance.

Reproducibility of Test

The several investigators concerned have used this method of test on repeated occasions and good reproducibility has been obtained both within the triplicate set of panels and also between investigators. Using this method, segregation between enamels having good and bad detergent resistance has been achieved *e.g.* initial visual attack was after 4 and ½ hrs. respectively.

Upon carrying out this test it will be apparent that the initial loss of gloss will tend to vary with the angle at which the panels are viewed and also the intensity of light during the examination. It is, therefore, recommended that initially the test used was a comparative method rather than an absolute one. After practice it has been proved by the investigators that absolute results can be obtained.

In the case of bath enamels the conditions are such that severe attack occurs in one hour. It is probably desirable, therefore, to restrict the test as recommended to sheet iron enamels or acid resisting cast iron enamels.

Effect of Detergent Concentration

The standard detergent solution was varied from ⅛ to ¼ to ½ per cent strength and the standard test carried out on one enamel. Results indicated that increasing the concentration accelerated the rate of attack. Thus by using a more dilute solution, it is probable that a wider spread between two or more enamels will be obtained. This may be of use for assessing non-A.R. bath enamels which show signs of attack after ¼ hr., using the ¼ per cent concentration.

Effect of Temperature of Test

An increase in temperature of test will increase the rate of attack and conversely reducing the temperature slows the rate of attack. In no case has any reversal of detergent resistance of two or more enamels been observed when tested at high and low temperatures. The effect of temperature variations is greater at higher temperatures than at lower ones and consequently only ± 1°C. is permissible in the recommended method of test at 96°C.

Comparison Between Several Test Solutions

Utilising panels coated with the same detergent-resisting enamel and fired at the same time, strictly comparable tests were carried out to observe the influence of the proposed standard detergent testing solution, sodium carbonate and sodium pyrophosphate, each at ¼ and 1 per cent concentration. The order of decreasing corrosiveness with the one enamel tested was :—

¼ per cent sodium carbonate.
1 per cent I.V.E. proposed standard mixture
1 per cent sodium carbonate.
1 per cent trisodium pyrophosphate.
1 per cent tetrasodium pyrophosphate.
¼ per cent I.V.E. proposed standard mixture.
¼ per cent trisodium pyrophosphate.
¼ per cent tetrasodium pyrophosphate.

It is thus apparent that the ¼ per cent sodium

(*Sodium dodecyl benzene sulphonate can be added as :—
Nansa S (Marchon Products Ltd.)
Norvan EL (Norman Evans & Rais Ltd.)
SDD No. 1 powder (Stockport United Chemical Co., Ltd.)
The Nansa S and Norvan EL contain 40 per cent of this organic material, while the SDD No. 1 powder is 95 per cent. In all cases the diluent is essentially sodium sulphate).

carbonate was the most corrosive and was more than the 1 per cent solution. In the other cases the corrosiveness was greater with the stronger solution. The proposed I.V.E. standard solution is more corrosive than the American favoured sodium pyrophosphate.

Effect of Fineness of Grind of Enamel

A known detergent-resistant frit was milled with 4 per cent clay using ammonium carbonate as electrolyte to $\frac{1}{2}$ gm., 1-2 gm. and 5-6 gm. on 200 mesh, employing a 50-cc. slurry sample, then sprayed on to ground-coated panels. All panels were fired together. On testing by the standard method the panels were graded $4\frac{1}{3}$, 3 and $2\frac{1}{16}$ respectively, indicating that finer grinding improves detergent resistance.

Effect of Firing

It was shown that both underfiring and overfiring of a known detergent-resistant enamel caused a deterioration in resistance even though the panel had a good glossy appearance. Slight underfiring had less effect than overfiring when assessed by the standard method.

Effect of Electrolytes

$\frac{1}{4}$ per cent additions of the following electrolytes were added to mills of a detergent-resisting enamel + 4 per cent clay + $\frac{1}{4}$ per cent bentonite + water. The slurries were sprayed on to test strips then fired together and subjected to the standard detergent resistance test :—

Ammonium carbonate control
Sodium nitrate
Potassium nitrate
Magnesium sulphate
Barium nitrate
Potassium chloride
Sodium nitrate
Sodium aluminate
Borax

Results indicated that all the non-volatile electrolytes caused a decrease in detergent resistance but that sodium and potassium nitrates had the least effect. The list of electrolytes as given represents the order of resistance to corrosion.

In a second series, blends of two electrolytes were added to mills of the same detergent-resistant frit and again it was shown that best resistance was obtained with a mill addition of $\frac{1}{16}$ per cent sodium nitrate plus $\frac{1}{16}$ per cent potassium nitrate.

It should be stressed that these results apply to the single frit tested and it is possible that other electrolytes may be superior in another enamel.

With the enamel used, optimum resistance was obtained with the following mill addition :—

Frit	100 parts
Clay	6 parts
Bentonite	$\frac{1}{2}$ parts
Quartz	2 parts
$NaNO_3$	1/16th part
KNO_3	1/16th part

Fineness : $\frac{1}{2}$ gm. on 200 mesh.

Effect of Milling Clay, Silica and Alumina

This variant was assessed using two base frits. In the first case the frit was milled with 2, 4 and 6 per cent clay, other factors being equal, and the detergent resistance assessed.

A second frit was milled with 2, 4, 6 and 8 per cent clay, using ammonium carbonate as electrolyte, and a standard with no clay or electrolyte, utilizing isopropyl alcohol as the medium.

Results

% Clay	Detergent Resistance Grading	
	Frit A	Frit B
0	—	1
2	$1\frac{1}{4}$	$5\frac{1}{2}$
4	4	$3\frac{1}{2}$
6	7	$1\frac{1}{2}$
8	—	$\frac{1}{2}$

Thus in the case of Frit A, an increase in clay caused an increase in detergent resistance. With Frit B, optimum results were obtained with a 2 per cent clay addition, further increments causing a decrease in resistance.

With the 0 and 4 per cent clay additions as standards the equivalent amounts of silica and alumina both separately and combined, as found in 4 per cent clay, were milled into the frit. Silica gel and alumina gel were used. After firing and testing under standard conditions it was apparent that the silica addition alone gave a better result than 4 per cent clay, while the alumina alone caused a decrease in resistance. The joint addition of silica gel and alumina gel resulted in an enamel having worse resistance than when 4 per cent clay was used.

A second frit was employed and it was shown that silica additions (as quartz) improved the resistance, whereas alumina additions again had a deleterious effect.

Explanations for these apparent anomalies regarding the influence of clay may be found either in the possibility that the extra clay has resulted in slight underfiring with one enamel, or that as the basic frit formulations are different so the mill additions are having varying effects.

Effect of Opacifiers

Two per cent additions of zirconium oxide, titania and tin oxide were made to a detergent-resistant enamel. After testing it was shown that they had a slight effect on detergent resistance.

	Rating
Standard	3
Standard + 2 per cent ZrO_2	3
Standard + 2 per cent TiO_2	$2\frac{1}{16}$
Standard + 2 per cent SnO_2	$2\frac{2}{3}$

Effect of Colour Oxides at Mill

A known detergent-resisting frit was milled with 4 per cent of a green, blue and cream oxide in addition to the usual mill additions. The fired panels after testing gave the following ratings :—

White Standard	3
Green	$\frac{1}{2}$
Blue	$1\frac{3}{4}$
Cream	$2\frac{1}{3}$

It is thus apparent that these additions can cause a decrease in detergent resistance. It should be indicated, however, that deeper colours tend to reveal loss of gloss easier than whites or paler pastel shades.

From personal experience one of the investigators had found that small additions of colours to a zircon-opacified bath enamel had no apparent effect on gloss retention.

Comparison between a soft Antimony and Zircon bath enamel

The zircon-enamel was shown to have slightly better resistance to the standard test solution than a soft antimony oxide-opacified dry process enamel. In both cases attack was progressive from $\frac{1}{4}$ to 1 hour. With the zircon-enamel the side which was cleaned each $\frac{1}{4}$ hr. showed better resistance than the unrubbed side but no such distinction was observed with the antimony enamel. The cleaned side of the zircon enamel was better than the cleaned side of the antimony finish but the unrubbed sides were very similar to each other. Furthermore, a different type of attack was apparent between these two dry process enamels in that the zircon finish suffered a uniform loss of gloss over the whole surface, whereas the antimony enamel exhibited a fairly uniform " background " attack with the superimposition of a large number of small areas showing more severe attack.

An interesting factor noted was that the BS.1344 alkali test indicated the antimony enamels to be superior but a 0.1 per cent Lux solution at 40°C. indicates that the zircon finish had better gloss retention, thus agreeing with the findings using the I.V.E. standard solution.

General Conclusions

1. Enamels vary in their resistance to detergent.
2. Detergents vary in their corrosiveness towards enamel.
3. The BS.1344 alkali resistance test is not indicative of detergent resistance.
4. The *p*H of detergents varies but, in general, corrosiveness is not directly related to *p*H.
5. Of the general enamels assessed, best resistance was obtained with the semi-opaque A.R. titania enamel, together with a specially formulated frit.
6. Acid-resisting cast-iron enamels were superior to the non-A.R. cast-iron enamel evaluated.
7. During enamel attack by detergents a scum forms on the enamel surface which, during the early stages, can be removed with an abrasive rubber or powdered frit.
8. The first sign of attack is apparent at the liquid/air interface.
9. Several types of equipment to measure detergent resistance were evaluated.
10. Enamel attack is best evaluated by visual assessment of initial loss of gloss ; weight loss figures and the pencil method of gloss assessment having been rejected.
11. The active ingredients in detergents were assessed using a dry process enamel and also two sheet iron enamels.
12. A reproducible method of test has been proposed using simple apparatus and employing a four component mixture which has been shown to be more corrosive than any detergent tested.
13. As the temperature of test or the concentration of test solution increase so the enamel attack is accelerated.
14. The test solution recommended is more reactive than the P.E.I. method but less reactive than $\frac{1}{4}$ and 1 per cent sodium carbonate solutions under the same conditions.
15. Finer grinding of the enamel improves detergent resistance.
16. Firing variations affect detergent resistance.
17. All electrolytes assessed cause a diminution in detergent resistance but, with the frit examined, sodium and potassium nitrates had the least effect.
18. Milling clay will influence detergent-resistance. In one case increasing clay had a beneficial effect but in another the resistance was at a maximum with 2 per cent clay.
19. Opacifiers can have a slight adverse effect on resistance.
20. Colour oxides can adversely affect resistance.
21. A zircon-opacified bath enamel was shown to have slightly superior resistance to an antimony opacified dry process enamel.

DISCUSSION

THE CHAIRMAN (Mr. S. A. E. Ryder) remarked that there was a very great deal of experimental detail described in the report. The Sub-Committee were concerned to improve the qualities of vitreous enamel, and progress in improving a product could not be made without having a yardstick with which to measure. The Sub-Committee, by supplying that yardstick, had assisted in the improvement of the alkali resistance of baths and other items.

MR. JACKSON said that in his view the terms of

reference of the Sub-Committee should be extended a little to include the working out of possible inhibitors in detergent solutions ; he had in mind particularly that higher silicate contents might be of value in this field. The silicates were known to inhibit the attack of caustic-soda solution on milk-bottle glass ; therefore, there was the possibility that some guidance could be given to users or manufacturers of detergents, who would make special mixtures for cleaning glass, and so on.

He was a little scared about the Sub-Committee's casual discarding of hard water. The housewife had not access to distilled water, although it was easy enough on a scientific plane to say that the easiest way to achieve standard conditions was to use distilled water. But the presence of calcium ions tended to increase the attack of mild alkalis on glasses, and he thought that enamels were of a similar nature.

In the report there was reference to trisodium pyrophosphate. In a number of detergents of the "Tide," "Omo," "Surf," class, he had gathered the principal polyphosphate was sodium tripolyphosphate. Did the Sub-Committee mean the same thing?

When the development of an accelerated test which could be used in the laboratory to evaluate the resistance of enamels against given conditions, was considered, it was possible to appreciate the desirability of using temperatures of 96°C. and concentrations of $\frac{1}{2}$ per cent in order to get relative results quite quickly. But the difficulty was that, with a much more slowly attacking solution there might be a change-over in the resistance, so that enamel A, which showed up better under that test than did enamel B, did not necessarily show up better than B in practice ; and it was possible that the conclusion about adding detergents to the alkali in the zircon/titanium enamel comparison might be false. Maybe in mild conditions a little of the detergent would not necessarily show that reversal.

He regretted that the report did not give figures to show the comparison of the tests. There was a list of solutions in the order of decreasing corrosiveness, and $\frac{1}{4}$ per cent sodium carbonate was at the top. The report stated, on the one hand, that it was not possible to give figures which meant anything, and therefore the Sub-Committee could only give a list ; yet at the same time they stated in the report that there was good agreement with triplicates. He assumed that they were satisfied that triplicates gave a statistically significant difference in performance. If that were so, it seemed that they could have given at least an indication of how much more corrosive was the $\frac{1}{4}$ per cent sodium carbonate than the 1 per cent sodium carbonate.

Finally, in Table I it was indicated that enamel No. VI was most resistant to the first three detergents, and others were less resistant, and No. I was most resistant to the fourth detergent. He felt that some further indication ought to have been given as to whether the order of differences was not of much significance.

He hoped that when tests were designed, the practical side would not be forgotten.

MR. MILLAR said that with regard to hard water, the terms of reference were to devise a method of test. He was not specifying hard water, it varied from area to area, and therefore distilled water had been used.

As to agreement between the results of different investigators and also between different sets of enamels, he had forgotten to mention in his resume, but it was described, that it was possible to give a numerical value for detergent resistance, and that was the time in hours to cause the initial loss of gloss. Using that as a yardstick correlation had been obtained between the different sets of enamels and also between the results of different investigators.

A range of temperature had been investigated with two enamels, and in no case was any reversal of results obtained.

He agreed that it would be better to have some sort of numerical values in the table referred to. To say that the alkali-resisting enamel was generally the best one was a general statement, and from the number of times that enamel occurred in the first three, that was the best one, together with the semi-opaque titania enamel.

The order of times should have been in the sheet, for the figures were available. It was also correct that in several cases the difference between any two enamels was not very great ; he could give the figures.

Standard Hard Water Solution

MR. JACKSON said it was quite possible to describe a standard hard water solution. Also, if the effect of a range of temperatures on two enamels did not produce a cross-over, it did not mean necessarily that there was not a cross-over in another case. If the Sub-Committee had the figures, why not publish them in the first place?

PROFESSOR A. I. ANDREWS said that he and his colleagues had run a tremendous number of tests on the water resistance of enamels, using waters of different kinds, and they had failed absolutely to find out what was the ultimate reason why some waters affected enamels and some did not. The nature and purity of the water had something to do with it ; he did not know whether it was the presence of gases in the water or what it was that upset all their efforts.

The report described an excellent piece of work. The attack on enamels was one of the most difficult problems when using water alone, and he sym-

pathised with the Sub-Committee in adding detergents and trying to find out what the story was. Pure water, of course, was very corrosive, but the factor required was not the purity of the water, or its acid nature. Occasionally there was the phenomenon that two waters which, so far as was known, were just the same, had very different effects in their attack.

Wear of Dark Enamels

A SPEAKER asked why the enamels used on washing machines were dark or dark mottled. Did the manufacturers think the dark enamels were harder wearing?

MR. R. M. WATTERS thought the dark enamels were used because they were more economical and harder wearing than the lighter ones.

MISS BEGRIE commented that if dark enamels were harder wearing than the lighter ones for washing machines they must also be for cooking or other enamelled appliances. But the manufacturers would not say so.

A SPEAKER said the colour of one well-known washing machine which had stood up as well as or better than any, was described officially as blue-grey with blue mottle. The colour was chosen because it gave the maximum resistance to whatever was put into the washing water.

THE CHAIRMAN commented that the colour of a washing machine in the conference exhibition was a very, very light pastel green.

Comparisons with U.S.A. and Continental Enamels

MR. WATTERS, who congratulated Mr. Millar and his Committee on their efforts, added that it was a pity they did not try the Continental and American enamels for comparison, which he thought would have proved that the British enamels were as good as any in the world today.

MR. MILLAR said the Committee did not make that comparison; there were a vast number they could assess. He did not think the Continental and American enamels were better than those of anybody else.

With regard to the comment by Miss Begrie, that if a dark enamel were best for a washing machine it should be best for a cooker, he pointed out that cooker interiors needed acid resistance, but not necessarily the same property was required in the washing machine.

MR. J. NICHOLLS (Vice-Chairman of Council), following up the reference made to Continental enamels, said there had been a glaring instance during the last month, when there were continued complaints of enamelling which was done in this country, purely because of faulty design. The people concerned got into a hopeless mess and could not see their way out of it. The enamelled items were supplied to Germany, whence the complaints originated, and the Germans had suggested that their enamel would stand up to the job better than ours. But the items when processed in Germany had also failed, and the Germans admitted that British enamels were superior.

A SPEAKER said it was always encouraging to see work of the kind described in the report being done, but he wondered about the interpretation of the results. In that connexion he mentioned a survey of cookers, their efficiency, the cleaning of them, and so on. Originally the work included baking food on samples of enamel. That could have led to serious derogatory remarks being made about the enamel.

He asked if now the time were ripe for an approach to detergent manufacturers to ask them to control the detergents, rather than having to condition the enamel to withstand attack by the detergents, which were becoming stronger and stronger, and the problem would be never-ending.

MR. S. HALLSWORTH (Past Chairman of Council) took the opportunity to congratulate not only Mr. Millar and his committee, but also the Institute of Vitreous Enamellers. Echoing the remarks of Mr. Grainger, he said that when the Institute had formed its first Standards of Resistance committee the bath manufacturers would not co-operate; and the meeting had heard some of the results. He paid tribute to the Institute for having taken up this question of detergents so quickly on behalf of the industry, and asked the company members and the companies using vitreous enamel if the work would have been done if it had not been for the Institute, which had been able to get together representatives of the various firms, who had published their results.

But it did not stop there. A committee had been formed to deal with detergents, it could be called together at short notice, and he thought the manufacturers of washing machines would derive benefit from it, as would the vitreous-enamelling industry.

The large manufacturers of washing machines had changed over from stainless steel linings to vitreous enamel. While he would not compare the resistance properties of the two, the change did show the value of investigational work which would improve the properties of vitreous enamel.

Co-operation with Detergent Manufacturers

MR. MILLAR, dealing with the point about co-operation with detergent manufacturers, said the British Ceramic Research Association were making a similar sort of investigation into attack by detergents. The addition of aluminium decreased the attack by the detergents on glazed finishes.

MISS HOUGHTON asked why the committee had directed so much of their work to the detergents

(*Continued in page* 102)

Problems of HIGH TEMPERATURE CORROSION in MODERN PROCESS PLANTS

by JOHN I. B. RUTHERFORD

THE earliest type of process plant vessel, was a cast-iron pot for boiling down sugar or salt, or else a copper vessel to distill alcohol from a fermented mash. Metallurgical knowledge restricted the size of cast-iron utensils and also the technique of joining and fabricating into complex components so, somewhat over fifty years ago, steel rapidly replaced cast iron in this field. Copper was the major constructional material in the beer and spirits industries until recently replaced by stainless steels. Today, steel and its various alloys are used almost exclusively as the materials of construction in process plants, although on occasions with the assistance of coatings and linings. Steel is cheap, strong but ductile over a wide range of temperatures, readily available, easily fabricated and is represented by a vast background of engineering experience. Unfortunately, it is not noble or inert. It has a tendency to corrode in various ways and must sometimes be considered expendable, hence the interest in this topic today.

The factors involved in the fabrication and installation of chemical processing equipment are quite complex. Steel structures for operation up to about 600°F. (315°C.) are designed on the basis of the elastic theory of stress distribution. This assumes that any safe load applied to the metal can be supported indefinitely and on removal, the metal will assume its original shape. At higher temperatures the metal behaves in a plastic manner. An applied load will cause a change in shape as a function of time, *i.e.* creep takes place. From a theoretical standpoint, at these elevated temperatures any load imposed on the metal, even its own weight, will ultimately cause failure by rupture. Herein lies the major difference between the behaviour of steel applied to processes at ambient temperatures and at elevated temperatures. The conventional steel storage tank, if protected from corrosion, may be expected to last indefinitely. A steel reactor vessel, say at 1250°F. (678°C.) has a limited life, related to design, which may be still further reduced by corrosion.

* Chief Metallurgist, The Babcock & Wilcox Company, Tubular Product Division, Pennsylvania, U.S.A.

Corrosion of steel is commonly associated with water in the liquid phase, and customarily is observed to progress more rapidly at higher temperatures. Water, however, converts to steam at 212°F. (100°C.), unless a pressure higher than atmospheric is maintained ; even then, many of the electrolytic aspects of corrosion are not observed at elevated temperatures. When they occur, it is in some unique environment such as by the breakdown of emulsions on heating.

The most prolific form of corrosion at elevated temperatures is oxidation. This occurs as a simple chemical reaction between iron and oxygen, following parabolic rates which depend on diffusion through the oxide phases. However, steel is not just iron, the environment contains other constituents than oxygen, the temperature seldom remains constant and mechanical stresses serve to modify what might otherwise be a simple system. A normal combustion atmosphere, for greatest efficiency, contains an excess of oxygen. While this oxygen content may be low, the volume of gas is large and generally passes over the metal surface at a high velocity in order to permit heat absorption by the vessel. Under ideal conditions, all parts of the metal surface will convert to oxide and the film will increase in thickness at a uniform rate with the passage of time. These conditions seldom prevail. Instead, non-uniform temperatures cause variations in scale thickness, so that the scale layer can be used to estimate temperature distribution.

The generic term " scale " refers to the oxide layer which forms on the metal, but this scale may be just as complex as the underlying steel. Iron oxide undergoes phase changes just as steel. It forms an infinite series of solid solutions associated initially with the chemical composition of the underlying metal and then subsequently modified by the diffusion rates of the various elements as the metal continues to be converted to oxide. A thick section of scale quite frequently consists of two or more layers of different chemical compositions and crystal structures.

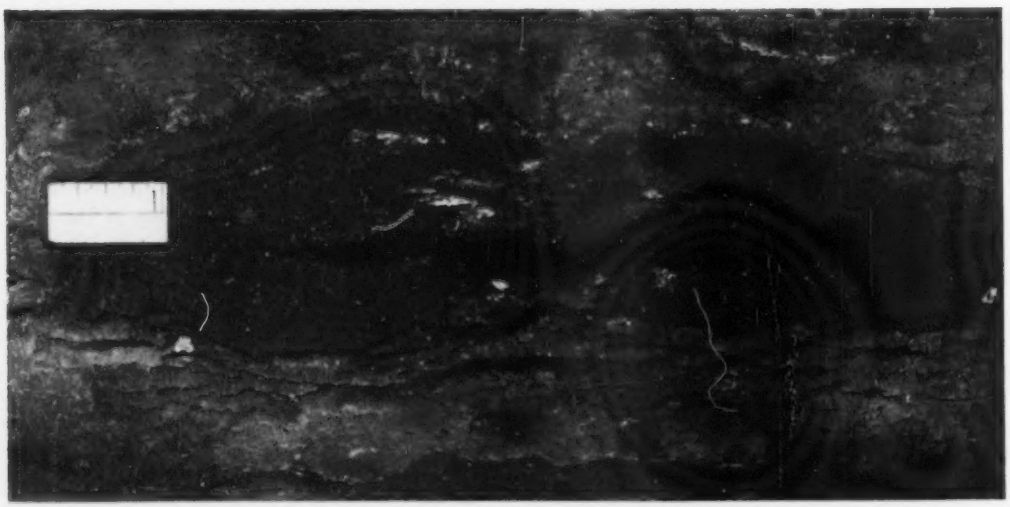
The mechanical properties of scale are radically different from those of the underlying metal. A

thin film, as represented by the bluing in gunmetal finish, is extremely tough and tenacious and it even offers some resistance to the rusting of steel in normal atmospheres. When this scale becomes bulky, it becomes refractory in all senses of the word, and is usually heterogeneous to the point that it exists in a series of finite layers. Changes in environment, whether combustion atmosphere, product mix or temperature, create discontinuities in the scale layer. Even when the chemical composition of the scale remains constant, a change in the rate of growth will modify the crystal structure, and just as in plant life, influence the mechanical properties.

The expansion coefficient of various scale compositions is significantly different by comparison with the underlying metal. Fluctuating temperatures, therefore, lead to cracking and spalling of the scale layer. Fig. 1, illustrating this point, shows a Croloy 5 steel tube after 6½ years of service, during which time cracks in the scale resulted in cracks in the metal. The rate of scaling decreases as the scale layer builds up, so when the scale flakes off, oxidation is accelerated at the exposed metal surface. Where the scale layer is retained, oxygen attacks the metal at the bottom of the crack, just as rain penetrates through cracks in the mud when a pond has dried up. Localized attack in this manner leads to crack propagation at the metal surface and a resultant loss of ductility of the metal from these stress-raisers. This is similar in many respects to stress corrosion. The ductility of scale is lower than the metal over a wide range of temperatures, except where the scale composition is modified to become a soft glass. Mechanical stresses applied to the metal will result in cracks being formed in the scale under circumstances when the metal will plastically deform. This condition is especially prevalent under cyclic stresses and the cracks constitute stress-raisers and loci of failure by fracture, analogous to corrosion fatigue. The rate of metal oxidation has been the subject of many investigations and all these researchers have one common conclusion ; that the *rate of oxidation is at a maximum at the outset, and decreases as the oxide film builds up.* A crack through the scale film exposes the underlying metal to this initial rate of reaction and therefore increases the rate of oxide penetration into the metal. Similarly, if the gas velocity at the metal surface is sufficient to sweep away the scale as it is formed, then the rate of oxidation will continue at the initial high rate of the fresh metal surface. This condition prevails when the metal is exposed to the impingement of a steam jet or a combustion flame.

While variations in metal temperature and non-uniform gas velocity represent the most common cause for irregularities in the rate of oxidation, there are other causes present within the metal itself. Segregation of chemical composition will lead to this behaviour, but, while this is found in castings, it is seldom observed in wrought steels. A large casting may exhibit a gross variation in chemical composition from one section to another, and also a variation within the small area encompassed within a dendrite. Fig. 2 shows the structure, at a magnification of 500

Fig. 1.—Croloy 5 tube after 6½-years service, showing cracking of scale and base metal.



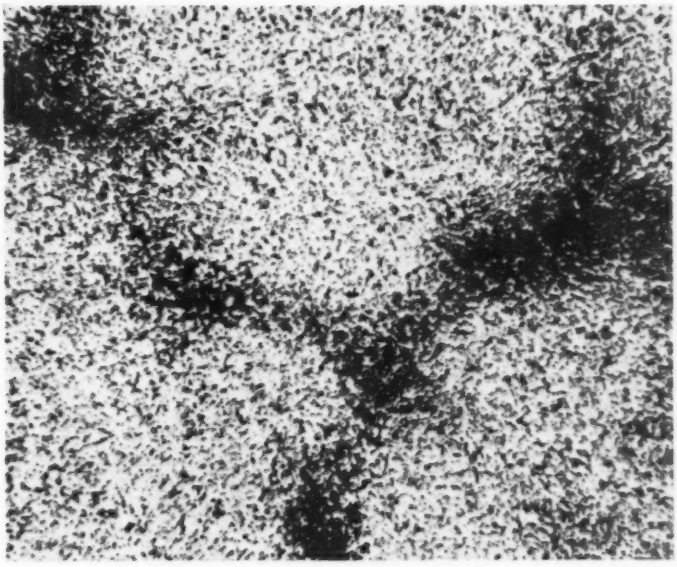


Fig. 2.—(× 500) Structure of 5 per cent. Cr., ½ per cent. Mo cast header.

times, of a 5 per cent chromium ½ per cent molybdenum cast header. The dendritism or coring is quite evident. This material was susceptible to temper embrittlement which is never found in commercial wrought materials of this type. A structural part which has been fabricated by welding will similarly show a non-uniform rate of scaling even though the weld bead has nominally a similar composition. Contamination of the weld by carbon, or increase of silicon to obtain fluidity, will materially influence scaling rate, especially as the size of the weldment is increased. Even in a homogeneous metal, it is commonly observed that *oxygen* (and other elements) *diffuse more rapidly at the grain boundaries than through the symmetrical lattice of the grain.* Since the concentration of oxygen is higher at this location, it is only natural that the oxide forms preferentially at the grain

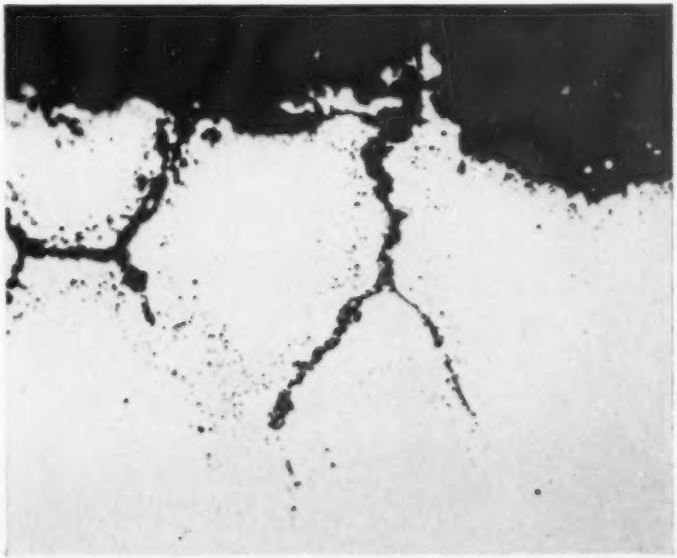


Fig. 3.—(× 100) Photomicrograph of Croloy 18/8 steam superheater tube after 8 years in service.

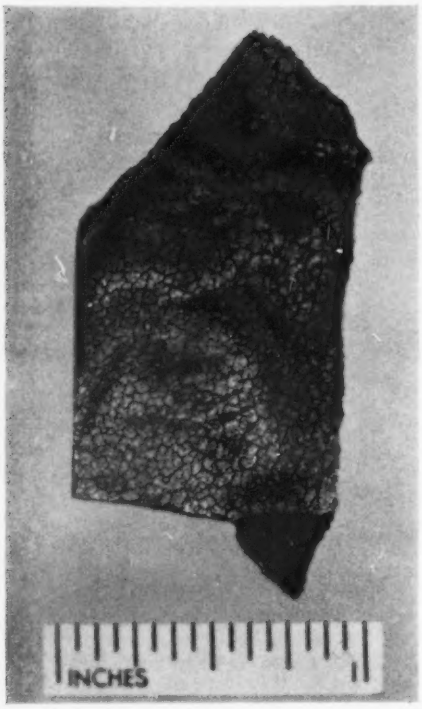


Fig. 4.—Outside surface of Croloy 5 reformer tube after 56,000 hours on stream.

boundaries. Under some circumstances, oxidation will occur at the boundaries considerably in advance of massive oxidation. This yields material at the surface which, while primarily metallic, lacks the cohesive characteristics of the original material and may even disintegrate in the manner of intergranularly corroded metal. This is clearly observed in Fig. 3, a photomicrograph, at 100 times magnification of a Croloy 18-18 steam superheater tube after 8 years in service. That this is not restricted to the austenitic stainless steels can be seen by Fig. 4 the outside surface of a Croloy 5 reformer tube after 56,000 hours on stream. Intergranular oxidation has also been found in low-carbon steels.

The advent of automatic controls for combustion and also in hydrocarbon reforming—the basis of the petrochemical industry—has led to conditions where oxidation is cyclic and is alternated with periods of carburization. Carbon is monatomic, has a small atomic radius which permits it to diffuse into the iron lattice with the same facility as oxygen, and then, when it exceeds the saturation limit, forms compounds with iron and many of the common alloying elements. In the application of thermal decoking in the oil industry, carbon deposits mechanically at the metal surface, then is removed by controlled combustion with oxygen in air, using steam as a quenching medium. Appropriate time and temperature combinations permit the coke to react with iron and from a layer of iron carbide, usually dispersed within the steel. Subsequent exposure to oxygen may

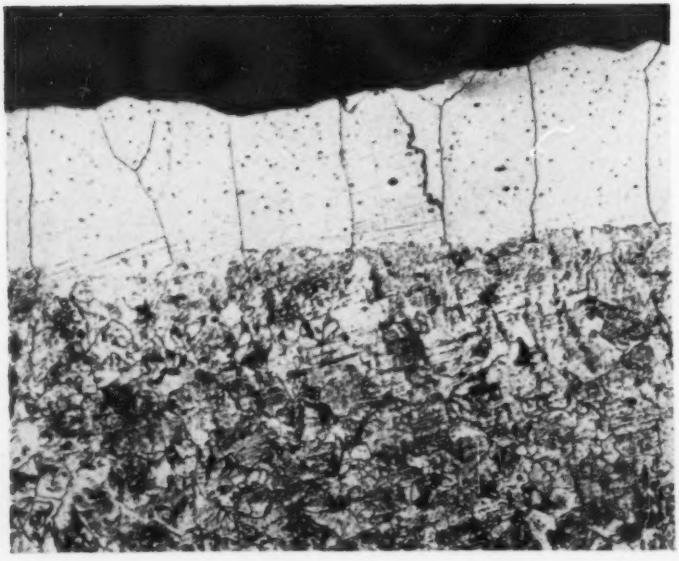


Fig. 5.—(× 100) Structure of surface adjacent to that in Fig. 4.

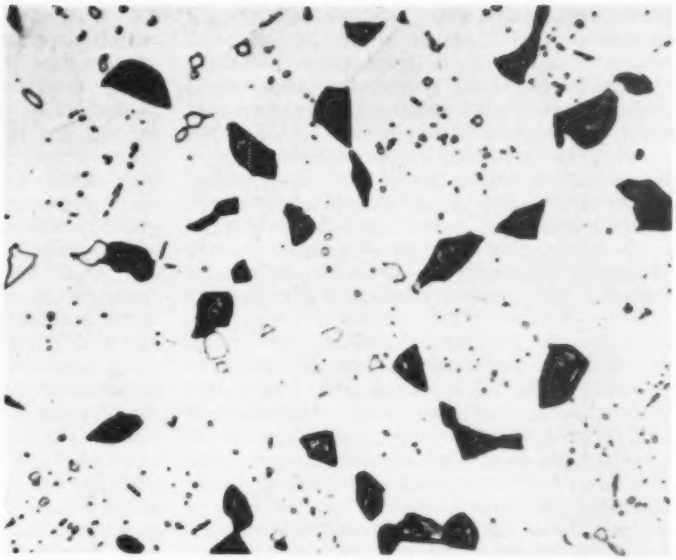
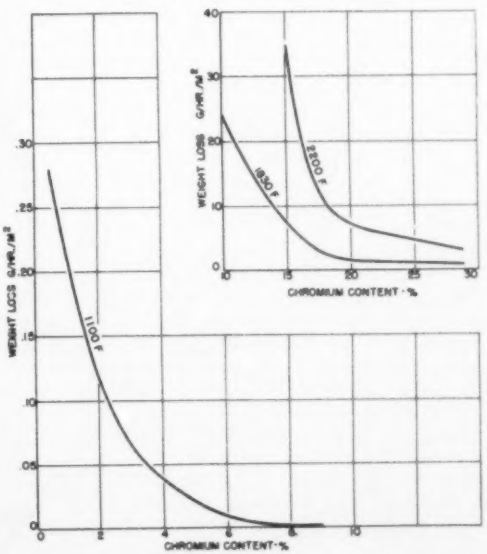


Fig. 6.—(× 500) Structure of Croloy 25-20 after extended service as an ethylene heater at 788°C.

reduce this carbide to iron, with the side reactions to carbon monoxide, carbon dioxide and iron oxides, but this iron is no longer a coherent, integral part of the original mass. The reduced iron from this reaction generally forms a dust of metal or oxide and, if the product flow has high velocity, may be encountered considerably downstream. The insiduous effects of this type of corrosion may be worse than mere metal wastage ; the dust may catalyze undesirable side reactions.

Steel and its alloys undergo structural changes during exposure at elevated temperatures and the structure has on occasions a more profound effect on corrosion than gross chemical composition. Diffusion of a restricted quantity of oxygen into steel serves to reorient the crystal lattice corresponding to the pattern prevailing at the original surface. This is shown in Fig. 5, a photo-micrograph, at 100 times magnification, taken adjacent to the surface shown in Fig. 4. This yields a columnar structure originating from the surface, with all the disadvantages of preferred orientation. The ductility of the metal may then be measured by its weakest plane, or even less if a continuous film of oxide act as a cleavage plane and stress-raiser from the surface. The chromium-depleted grain boundaries which are susceptible to attack by aqueous reagents are also susceptible to attack by oxygen, especially in highly stressed parts. Preferential oxidation at the grain boundaries has been observed in lower-chromium steels, unalloyed steel and in nickel alloys (other than steel). The dangers from this type of corrosion are difficult to establish since the external surface might appear sound and the quantity of metal converted to oxide might be small, but the effect on the mechanical properties of toughness and ductility are pronounced. Carburization of ordinary steel tends to reduce the rate of scaling since generally oxygen will combine with carbon, to evolve CO, before it will combine with iron to do permanent harm. In the case of chromium-containing steels, however, carbon com-

Fig. 7.—Effect of Cr. content on weight loss.



bines preferentially with chromium and leaves a chromium-depleted matrix which enhances the rate of scaling. The high-chromium steels are susceptible to sigma phase formation which jeopardizes mechanical stability. Since sigma constitutes a chromium-iron compound which is rich in chromium and leaves depleted surroundings, it also enhances scaling rates. Fig. 6, a photomicrograph at 500 times magnification, shows clearly the different rate of attack by etching reagents in the sigma series, by comparison with the austenite. This material is Croloy 25-20 after extended service as an ethylene heater at about 1450°F. (788°C.).

In the construction of heating equipment, proper design will restrict the rate of heat input so that the metal will operate at a safe temperature level. The greatest boon in the application of heat-resisting materials, is in the addition of chromium as an alloying element to steel. The well-known stainless steels were found during researches for metals to withstand the heat of engine exhaust valves, cannon and thermocouple protective sheathes. The association of chromium and oxygen which contributes passivity and "stainlessness," also serves to reduce the rate of progressive oxidation or scaling. The phenomenon of stainlessness is observed abruptly on the addition of about 10.5 per cent of chromium to iron (one atom in eight) and then is relatively little affected by further addition of chromium. Scaling or oxidation rates, on the other hand, tend to reduce continuously with increase in chromium content, especially at higher temperature levels. Fig. 7 illustrates the influence of chromium in reducing the rate of oxidation of steel. Because of the great disparity of rates between alloys within the range encompassed, it was necessary to use widely different test temperatures between the high and low chromium alloys.

One word of caution however; because of the high affinity between chromium and oxygen, stainless steels will oxidize in "neutral" atmospheres where steel will stay bright. There are a large number of chromium, steels to choose from, depending on other characteristics required; steels may be safely used up to 1200°F. (648°C.) with 5 per cent, 1600°F. (870°C.) with 18 per cent and 2100°F. (1148°C.) with 28 per cent chromium. Aluminium and silicon additions to iron, aid in resistance to oxidation under restricted conditions, but add considerable complexity to steel making. Carbon retards the rate of scaling by sacrifical effort, but the benefits are fleeting. Nickel and molybdenum are commonly found in heat-resisting alloys because of their beneficial effects on mechanical properties; they do not help resist oxidation, in fact, molybdenum may work seriously in the opposite direction. Coatings have been developed on a commercial basis to protect metals from excessive oxidation. Chromium, aluminium and silicon have been diffused into steel surfaces by process of chromizing, calorizing and ihrigizing respectively. These have all found useful application even though high alloys of these elements are extremely brittle, and the coatings are only effective when continuous. *Where metal surfaces are exposed to radiation and high-temperature gases,*

Fig. 8.—(× 500) *Photomicrograph of* 321 *steel after being abraded with metallic zinc and then welded.*

as in the development of jet engines, enamel coatings have proved an effective barrier to oxidation. These coatings are generally composed of a chromium-oxide base and are so constituted as to be plastic at operating temperatures, yet not so fluid as to drain or permit rapid diffusion.

Metals suffer other diseases at elevated temperatures besides oxidation. Copper, zinc and other low-temperature melting-point metals, when present on the surface of steel exposed to tension stresses at elevated temperatures, will penetrate at the grain boundaries and embrittle the metal. Fig. 8 is a photomicrograph, at a magnification of 500 times, of Type 321 which was abraded with metallic zinc and then welded. Zinc has penetrated at the grain boundaries in the heat-effected zone where thermal stresses were high. This test served as a demonstration of conditions which might occur with bad practices. *Steel should not be fabricated for elevated temperature use by copper, brass or bronze implements.* Furthermore, precautions should be taken against marking steel parts with paints or pigments containing oxides of these metals. These colouring pigments are generally made with an organic vehicle which, on heating, reduces the oxide to a metal and they alloy with the steel at the grain boundaries or slip planes, preferentially. Other metallic oxides attack steel at elevated temperatures. Vanadium pentoxide has a melting point about 1275°F. (690°C.) and reacts quickly with iron oxide. The eutectic of vanadium and iron oxides melts about 1180°F. (635°C.). Even chromium oxide, which is very refractory and protects stainless steels, combines with vanadium pentoxide and slags off without offering any protection to the metal. Sodium salts, sulphates, sulphides, carbonates, borates, etc., have low melting points and wash-off scale at elevated temperatures just as fluxes are used to remove slag in brazing. In the Kraft process of the paper industry, black liquor is burned to recover sodium sulphate, and these salts are highly corrosive to metal above 900°F. (482°C.).

A peculiar phenomenon described as "catastrophic oxidation" occurs with the molybdenum containing grades of steel. This behaviour is autocatalytic and should not in fairness be attributed entirely to environment. A steel containing 15 to 20 per cent chromium will normally withstand progressive scaling at about 1600°F. (870°C.). A similar composition containing 3 per cent molybdenum evolves molybdic oxide (vapour) at a very slow rate so that the gas is dissipated in the surrounding atmosphere. Under conditions where the atmosphere is stagnant, for example in a small orifice, the molybdic oxide accumulates and enriches in the scale layer to break down the protection it affords the metal. Molybdenum does not lower the scale melting point to form a slag like vanadium, but is equally potent in forming a loose, dry scale.

Sulphur attacks metal at elevated temperatures by the chemical reaction of forming sulphides. It attacks steel, in a manner similar to oxidation, above 700°F. (370°C.). The addition of chromium to steel prohibits sulphidation and oxidation, so high-chromium steels have given excellent service in oil-refinery heating furnaces, exposed to furnace gases on one side and high-sulphur crudes on the other. The austenitic stainless steels are excellent for this service, even though containing nickel which in itself reacts readily with sulphur. Chlorine reacts with iron at elevated temperatures, and some relief is obtained by the addition of silicon, although chromium seems to have no benefit.

Hydrogen does not corrode steel at elevated temperatures, in the customary sense of the word, but it may influence mechanical properties. Hydrogen is encountered at elevated temperatures in the reforming of hydrocarbons and also from corrosion by high-boiling-point saline solutions. Caustic solutions are evaporated, by superheated steam, in concentrations up to about 25 per cent in steel tubes, then in nickel steel to about 35 per cent, and then in pure nickel or Monel metal to the dry salt. Corrosion here, consists of simple solution of the metal although "caustic embrittlement" may occur where the metal is stressed. Concentrated sulphuric reagents, in sulphonating hydrocarbons, are treated at elevated temperatures in silicon-iron alloys or molybdenum complexes. Hydrofluoric acid for alkylation reactions is handled mainly in steel equipment although the reaction products are handled by nickel or molybdenum alloys. Phosphoric acid, used in phenol manufacture, may be handled by nickel steels or stainless steels, although precautions are necessary.

The most modern field of high-temperature corrosion, involves the transfer of energy from nuclear fission reactions. This field has been classified until recently. Sodium or sodium-potassium alloys are used for this purpose and come into contact with steels up to 1200°F. (648°C.). The main chemical side-reactions involve the presence of oxygen as a contaminant. At these "unusually" low temperatures, ordinary steels readily decarburize and, if part of the same system, stainless steels will carburize. Molten metals, bismuth alloys, etc., also act as oxygen carriers. Mercury has been used in power boilers for many years, and offers no chemical complications if handled in chromium steels and treated with inhibitor against oxidation-reduction reactions. Some of the latest reactors are designed for use with high-purity water. This would seem to solve all the boiler problems associated with feed water, oxygen, alkalis, chlorides, etc. The recently de-

(*Continued in page* 111)

FINISHING POST

A SELECTION OF READERS' VIEWS COMMENTS AND QUERIES ON METAL FINISHING SUBJECTS . . . . . .

Corrosion Science Society

SIR,

You kindly print the announcement of the formation of the Corrosion Science Society in your February issue, and you comment on the matter in your editorial "Who Speaks for Corrosion?" Will you allow me space to emphasize, on behalf of the sixteen signatories of the announcement (J. B. Cotton, C. Edeleanu, H. K. Farmery, W. F. Higgins, J. G. Hines, T. P. Hoar, E. A. G. Liddiard, G. Meikle, J. E. O. Mayne, R. N. Parkins, P. M. Raine, T. K. Ross, L. L. Shreir, H. T. Shirley, K. A. Spencer, J. N. Wanklyn) that our primary aim is to advance corrosion science by holding regular symposia on *corrosion research and development in progress*. This aim does not exclude a proportion of papers or lectures on completed researches or on established matters, but as you are aware, several other bodies already provide opportunities for their presentation. In particular, the Corrosion Group of the Society of Chemical Industry has in recent years promoted many important meetings of this type, and through its Education Panel has done a good deal to stimulate interest in the teaching of corrosion science: while the Institute of Metal Finishing, which is holding some 60 local-section meetings this session, is devoting no fewer than 14 of them to lectures and papers on corrosion and protection.

Far from wishing to compete with these and other similar activities, the Corrosion Science Society will try to supplement them. It is an entirely independent body consisting only of scientists with main interests in the field of corrosion and protection, and it will try to encourage the most informal exchange of ideas and experience amongst such scientists. Research in its earlier stages can often be greatly assisted by discussion amongst colleagues, before it is definitive enough for didactic presentation to a wider audience. At our meeting in April, we shall have sixteen talks by workers from four countries, and the main aim is cross-fertilization rather than dissemination. If later on our discussions come to include an increasing proportion of definitive work, we shall none the less expect to discuss it while it is still new.

In fact, sir, the Corrosion Science Society does not presume to "speak for" corrosion (which surely speaks for itself); only to talk about corrosion science, and, we hope, advance it.

Yours etc.,
T. P. Hoar.

University of Cambridge,
Department of Metallurgy,
Pembroke Street,
Cambridge.

Effect of Detergents on Vitreous Enamel

(*Continued from page* 94)

used for the delicate fabrics, and which were not so likely to be used in washing machines; e.g. "Lux," "Dreft" and "Sylvan."

MR. STILTON replied that the committee had chosen "Lux" and "Sylvan" as being examples of fairly pure commercial soap, whereas if they had bought a bar of soap they would not have known how much of it was soap. He then said that the main domestic detergents had been considered and then the Committee devised something which was even more vigorous than any of them.

MR. MILLAR agreed. He added that of the detergents which had been tried, the most corrosive was the mixture of palm oil soap, soda ash, sodium perborate and sodium tripolyphosphate. The synthetic detergent built up as a standard was equal to that. In other words, the most corrosive composition was used as the basis of the work.

MR. FINON asked whether the committee's report was unanimous or whether there were any dissentients.

He was rather sorry the committee had not gone further with the loss of weight test. If they did not want that test, what about examination by the new machine for the actual loss in reflection, which he thought was pretty sound too?

MR. MILLAR replied that the report was unanimous.

With regard to the loss of weight test, some erroneous results were obtained at first when comparing the visual effects with loss of weight; sample A was better than B at first, but after eight hours there was a reversal. He agreed that it was possible to formulate a method which would overcome that trouble, but it had been decided that it was a visual effect which was causing the difficulties, so that if visual examination was incorporated in the test it would be nearer to the true effect which was happening in service.

CONTINUOUS OXIDATION OF ALUMINIUM FOIL FOR ELECTROLYTIC CONDENSERS USING ALTERNATING CURRENT*

By B. M. TAREEV† and M. M. LERNER†

AT the present time the anodic oxidation of foil for electrolytic condensers is carried out on an extensive production scale using direct current by continuously drawing the foil through aqueous solutions of boric acid and borax [1-3]. Increased outputs of electrolytic condensers in recent times have led to investigations into the possible adoption of alternative methods because the above method produces :

1) considerable losses of electrical energy due to the necessity to transform alternating current into direct current, normally by rotary generators ;

2) large expenditure on the operational maintenance of generators, which work under frequent short-circuit conditions, caused by the foil breaking, an unavoidable feature in the anodizing baths under production conditions ;

3) reduced anodizing rate due to polarisation on the electrodes of the bath.

For anodizing of aluminium, and also of tantalum and certain other barrier-layer metals, it is possible to use alternating current, making use of the unilateral conductance of the oxide film of these metals ; attention to this has also been drawn by Günterschulze and Betts[4]. Deposition by alternating current is more economical than with direct current, subject to the reduction of the return currents through the oxide film (*i.e.* of the current in the direction of conductance through the film) and an improvement in the quality of the film. This condition may be ensured by the use, for instance, of two anodizing baths connected in a differential circuit (two-phase anodizing) [5, 6].

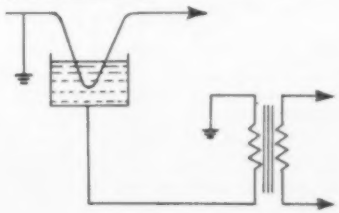
It is also possible, however, to use another method of limiting the return current. The processes which take place during anodizing with alternating current, are substantially dependent on the ratio, n, of the moduli of resistance of the foil, R_f, and of the bath, R_b [7]. If the bath is fabricated in a material which is subject to anodic attack, in aluminium for instance, and at the same time the surface area of the bath is of the same order or less than the surface area of the foil (*i.e.* n is close to unity), then it is possible to form a high-quality oxide layer with low consumption of electrical energy, if anodizing is conducted in only one bath (single-phase anodizing). In this instance the bath itself limits the return currents flowing through the foil.

The use of alternating current for continuous anodizing under production conditions requires the solution of a series of problems, primarily of those such as the choice of the method of limiting the return currents, the selection of a material for the bath which is not subject to anodic attack, and an investigation of the stability of the working conditions of the process.

Single-Phase Continuous Anodizing

Fig. 1 is a diagram of the single-phase circuit of a continuous anodizing plant consisting of only one bath and it is necessary to consider the ratio between the surface area of the foil and of a bath of the design which is generally adopted in the production of electrolytic condensers. A cross-section of a bath in such a plant is shown in Fig. 2. The reaction surface area of the bath, taking into account the surface area of the cathodes and of the holders is of the order of 5×10^4 sq. cm. The surface area of the section of polished foil on which the applied voltage occurs, in a bath 3.6 m. long is of the order of 2×10^4 sq. cm. Consequently for this polished foil n = 2.5. During the drawing of etched foil through the bath, n is dependent on

Fig. 1.—Circuit diagram for the bath during single-phase dynamic anodizing.



Elektrichestvo, 1959, *No.* 6, *p.p.* 71-76.

†(The authors are with the All-Union Correspondence Institute for Power Engineering, U.S.S.R).

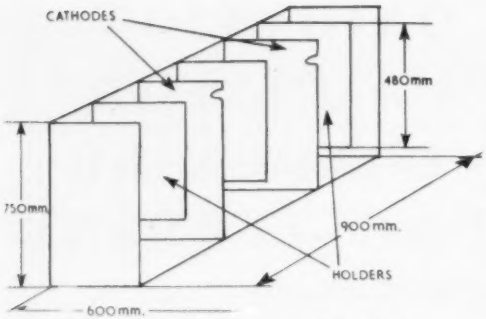


Fig. 2.—Design of the bath of an anodizing plant.

the coefficient of the increase in the surface area of the foil (the etching coefficient) ; where the etching coefficient is 2.5, n thus becomes unity.

By adopting a " coefficient of utilization " of the anodizing voltage, K, the value which indicates what portion of the voltage applied to the bath occurs on the surface of the foil can be calculated. If the bath and the foil are both aluminium, then $R_f = nR_b$ and

$$K = \frac{R_f}{R_f + R_b} = \frac{n}{n + 1} \qquad (1)$$

The use of foil with an etching coefficient of from 1 to 5 leads to a change in K from 71 to 38 per cent. As K determines the value of the voltage occurring on the oxide layer, upon which the thickness and consequently the volume, of the oxide layer is dependent, and if the steep gradient of the relationship between K during single-phase anodizing in an aluminium bath and the properties of the foil passed through it, which may vary within wide limits, is also taken into consideration, the conclusion is reached that single-phase anodizing in an aluminium bath is not suitable for application under production conditions.

Two-Phase Continuous Anodizing

Two-phase continuous anodizing in two baths connected in a differential circuit may be carried out by one of the two methods shown in Fig. 3. The use of either of these circuits can avoid short circuits in the electrical supply if foil breakage occurs during anodizing ; if the foil breaks in one of the baths, all the voltage will be applied in the second bath. The current in the circuit rises, but it will be limited by the sufficiently large resistance of one bath. In this instance instead of two-phase there will be single-phase anodizing. A full short-circuit can only occur when there is simultaneous breakage of the foil in both the baths, which is not likely to occur.

During anodizing with direct current, when up to ten strips of 50 to 80 microns in thickness are drawn through the plant, short circuits of the supply due to rupture of the foil occur relatively frequently (on average up to 4 per 24 hours in one plant). During single-phase a.c. anodizing the number of short circuits may remain just as great, but a transformer withstands a short circuit much more readily than a direct-current generator. Elimination of short circuits in practice is only attained where the baths are connected in a differential circuit, and this is a very definite advantage of two-phase dynamic anodizing over other methods.

During anodizing using the diagram shown in Fig. 3 (a) two separate units each consisting of one complete bath, are connected to one source of supply. It would be most convenient if in both units the surface of the foil was at the same voltage, *i.e.* the anodizing voltages in both baths should be equal to one another. For this it is necessary that both the baths should have the same resistance ; this could be ensured by identical anodizing conditions in the baths in respect of temperature, concentration of electrolyte and dimensions of the foil being passed through them. Deviations in the anodizing conditions from this ideal will lead to distortion of the voltages in the baths and a change in the dimensions of the anodized materials taken from each of the baths. However, it is difficult to ensure that the currents are the same and this is a disadvantage of the circuit shown in Fig. 3 (a).

During anodizing using the circuit shown in Fig. 3 (b), both baths form one anodizing unit, and the properties of the foil taken from the unit are determined for the most part by the voltage in the bath. If the electrolyte has an identical

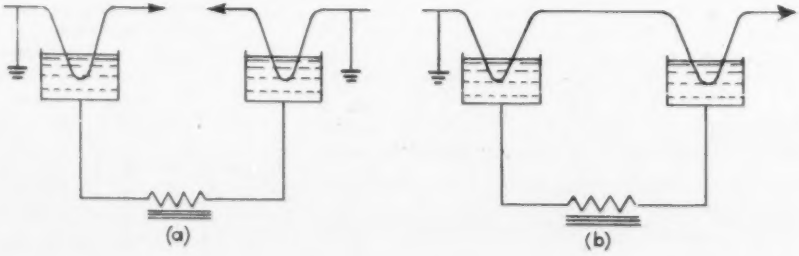


Fig. 3.—Circuit diagrams of two baths for two-phase continuous anodizing.

composition in both the baths, then the voltage in the first bath will always be less than in the second, since the combined resistance of the first bath is less than the combined resistance of the second. This is explained by the fact that unanodized foil passes into the first bath, while foil already anodized in the first bath passes into the second. Anodizing in a unit consisting of several baths, through which the same foil is drawn, and to which various voltages are applied, is termed stage anodizing. Operating with direct current a voltage is applied to each of the baths from a separate source of supply.

During two-phase anodizing with alternating current and using the circuit shown in Fig. 3 (b), there is also a graduation of voltages from bath to bath. But with alternating current the voltages which are applied to the baths from a single source of supply are established automatically and are dependent upon the anodizing conditions governing the various baths. This is the great advantage of this method.

From equation (1) it is evident that during single-phase anodizing, where the resistance of the foil greatly exceeds the resistance of the bath ($n \longrightarrow \infty$), the coefficient of utilization of the anodizing voltage is close to unity, so that the return currents and the current losses rise sharply during anodizing. Two-phase anodizing in baths connected in a differential circuit continuously limits the return currents through foil which happens to be under a negative potential in one of the baths, since in the second bath it is at the same time subject to a positive potential and allows a small direct current to pass. Thus two-stage anodizing where $n \longrightarrow \infty$, ensures a small current demand during anodizing and a high " coefficient of utilization " of the anodizing voltage. Where the resistance of the foil is of the same order as the resistance of the bath (*i.e.* n is close to unity), there is a drop in the " coefficient of utilization " of the anodizing voltage, and anodizing becomes uneconomical. In order to ensure anodizing at $n \longrightarrow \infty$, it is necessary for the surface area of the bath to be very much greater than the surface of the foil, if the bath is fabricated in a material susceptible to anodic attack (aluminium, for instance), or that the baths shall be fabricated in a material which is not susceptible to anodic attack.

In existing anodizing plants the surface area of the bath is of the same order as the surface area of the foil ; consequently the bath must not be fabricated in aluminium. Therefore for two-phase anodizing in plants of existing design the baths should be of material which is not susceptible to anodic attack. Such a material should not dissolve to any appreciable extent in the electrolyte on the application of current, especially if on its dissolution foreign elements are formed which are capable of leading to corrosion of the aluminium foil, and should also be sufficiently strong and cheap.

For this purpose investigations were carried out with various materials among which the most serviceable proved to be type 1Kh18N9T (YalT), so-called chrome-nickel-titanium steel. (The Russian designation of this steel indicates that it contained approximately 1.1 per cent. C, 18 per cent. Cr, 9 per cent. Ni and 1 per cent. Ti).

Stainless steel of this type underwent long-term experiments under production conditions. Initially the electrodes (cathodes and holders) were fabricated from this steel, and were put into service under production conditions for a period of several months in an anodizing shop working with alternating and direct current. During this time the steel did not suffer from anodic attack, and did not contaminate the electrolyte. Similar results were obtained during operational service over a period of a number of months of a unit fabricated completely of this stainless steel.

Stability of the Working Conditions During Continuous Anodizing with Alternating Current

Stability of the working conditions is characterized by a value which indicates by how many per cent. the voltage applied to the foil can fluctuate during the anodizing process. The stability of the voltage applied to the foil in the last bath of the plant has an especially great importance, for in this bath the quality of the foil produced during anodizing is determined.

Single-phase anodizing is more economic from the aspect of power consumption, when the resistance of the foil is of the same order or less than the resistance of the bath, but under such conditions the " coefficient of utilization " of the anodizing voltage is small and is sharply dependent upon the change in the ratio between the resistances of the foil and the bath. Thus during the process of single-phase anodizing under such conditions the voltage which occurs on the surface of the foil will be sharply dependent on the unevenness of the etching of the foil being passed through the bath ; this may change appreciably (by 75 per cent.) between one coil and the next. Consequently, the operating conditions of dynamic single-phase anodizing are unstable.

During two-phase anodizing the stability of the working conditions is substantially dependent on which of the two diagrams shown in Fig. 3 is used for process. In both instances the baths will be considered as being fabricated in a material which is not susceptible to anodic attack, and that the resistance of the baths by comparison with the resistance of the foil may be neglected. During anodizing in accordance with Fig. 3 (a), it is necessary to ensure equilibrium between the con-

ditions in the two baths. If the relative change in the resistance of the baths is designated by $\triangle R$, and the relative changes in the voltages in the first and second baths by $\triangle V_1$ and $\triangle V_2$ respectively, then it is not difficult to derive the following relationships :

$$\triangle V_1 = \frac{\triangle R}{2 + \triangle R}, \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

$$\triangle V_2 = \frac{\triangle R}{2 + \triangle R}; \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

If as a first approximation it is considered that $\triangle V_1$, $\triangle V_2$ and $\triangle R$ are real values, then from equation (2) and (3) it follows that the relative change in the voltage measured between the foil and the bath is not more than about one third of the relative change in the combined resistance of the foil and of the electrolyte in the bath. Fig. 4 gives the relationship between $\triangle V_2$ and $\triangle R$ (curve 1) for the diagram shown in Fig. 3 (a).

If the electrolyte in both the baths is identical, then during anodizing in accordance with this circuit the combined resistance of the foil and the electrolyte to the alternating current is less in the first bath than in the second. This is explained by the fact that unanodized foil passes into the first bath, while foil which has already been anodized in the first bath passes into the second. In this event the resistance in the second bath will be n times greater than the resistance in the first bath. It is not difficult to show that if, under the influence of a change in temperature, the concentration of the electrolyte and other causes, there is a change in the resistance of the foil in the first bath, then as a first approximation

$$\triangle V_1 = \frac{n\triangle R}{1 + n + \triangle R}$$

and

$$\triangle V_2 = - \frac{\triangle R}{1 + n + \triangle R}$$

If the change in the resistance of the foil and the electrolyte takes place in the second bath, however, then

$$\triangle' V_1 = \frac{\triangle R}{1 + n + \triangle R}$$

and

$$\triangle' V_2 = \frac{\triangle R}{n(1 + n + \triangle R)}.$$

Thus, when the circuit shown in Fig. 3 (b) is used, the same absolute change in the resistance of the foil and the electrolyte in the first and the second bath leads to different changes in the voltage measured between the foil and the last bath. If there is a change in the resistance in the second bath, then the relative change in the voltage measured between the foil and the second bath is n times less than the relative change in the voltage in the instance where the resistance in the first bath is changed. The relationships between $\triangle V_2$ and $\triangle' V_2$ on the one hand and $\triangle R$ for various values of n is shown in Fig. 4 (curves 2-4 inclusive and 5-7 inclusive respectively).

Thus in other words the use of circuit in Fig. 3 (b) makes it possible to increase the stability of the voltage measured between the foil and the baths by comparison with the circuit in Fig. 3 (a).

Hitherto only the combined resistance of the foil and the electrolyte in each bath has been considered. But it is important to establish within what limits there is a change in each of these resistances in relation to the various parameters under production conditions, and in this connexion what changes may be expected in the voltages measured between the foil and the bath.

On the temperature are dependent both the resistance of the sheet and also that ot the electrolyte. Assume, however, that the temperature exerts a substantial influence only on the resistance of the electrolyte, and that its influence on the resistance of the foil may be disregarded.

Anodizing in production plants takes place at a temperature of 85 to 95° C. It will be assumed that anodizing is conducted with alternating current in electrolytes which are normally used for anodizing with direct current, and which have compositions in accordance with those in Table I.

For the electrolytes indicated in the table the relationship between the specific resistance and temperature is given in Fig. 5, from which it is evident that where there is a change in temperature of 10° C., the change in the resistivity of an electro-

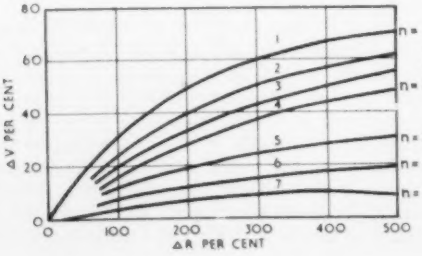


Fig. 4.—The relationship between the relative change in the voltage ($\triangle V_2$) in the second bath and the relative change in the resistance ($\triangle R$) of one of the baths. (**see** *circuit diagrams in Figs. 3(a) and 3(b).* 1 : *anodizing in accordance with diagram 3(a), where* $R_1 = R + \triangle R$ *and* $R_2 = R$; 2, 3, 4, ; *anodizing in accordance with diagram 3(b), where* $R_1 = R + \triangle R$ *and* $R_2 = nR$; 5, 6, 7, : *anodizing in accordance with diagram 3(b), where* $R_1 = R$ *and* $R_2 = nR + \triangle R$.

Table I

Composition of Electrolytes for Anodizing

Number of Composition (*see* Figs. 5 and 6)	Anodizing Voltage, V	Composition of Anodizing Electrolyte		
		Distilled Water cu. cm.	Boric Acid gm.	Borax gm.
1	Up to 550	1000	100	0.5
2	550 - 650	1000	50	0.25
3	650 - 800	1000	30	0.05

lyte does not exceed 10 per cent. Consequently the voltage in the last bath changes in accordance with Fig. 3 (a) by 4.8 per cent., and in accordance with Fig. 3 (b) (where n = 2) by not more than 3.2 per cent. (*see* Fig. 4). And so the change in the voltage in the last bath, where the circuit as Fig. 3 (b) is used, is very small and may be disregarded.

The resistivity of the electrolyte may be affected not only by a change in temperature, but also in the concentrations of boric acid and borax in the electrolyte. During the anodizing process the change in the concentration of these components in the electrolyte takes place mainly for two reasons : due to the intensive evaporation of water and the accumulation of aluminium hydroxide in the bath.

Fig. 6 shows the change in the resistivity for the various compositions of electrolyte due to evaporation of the water. Normally evaporation of water before correction of the composition in the baths takes place within the limits of 5 to 7 per cent. Consequently the resistivity changes approximately by 10 per cent., while the voltage changes by 4.8 per cent. in accordance with Fig. 3 (a) and by 3.2 per cent. in accordance with Fig. 3 (b), where n = 2 (*see* Fig. 4).

The change in the content of water in the electrolyte as a result of accumulation of aluminium hydroxide amounts to about 5 to 10 per cent. during the course of 240 hours, *i.e.* until the bath is due to be washed out. This should also lead to a change in the resistivity by approximately 24 per cent., and in the voltage by 10 per cent. in accordance with Fig. 3 (a) and by 7.7 per cent. according to Fig. 3 (b), where n = 2.

The change in the concentration of the electrolyte, as a result of the evaporation of the water and the accumulation of aluminium hydroxide, takes place to an almost equal extent, simultaneously and in one direction, in both the baths ; therefore the change in the concentration of the electrolyte in one bath by comparison with that in the other should be considerably less than the absolute change in the concentration in each of the baths. Consequently, the change in the concentration of the electrolyte should have little influence on the stability of the working conditions for anodizing,

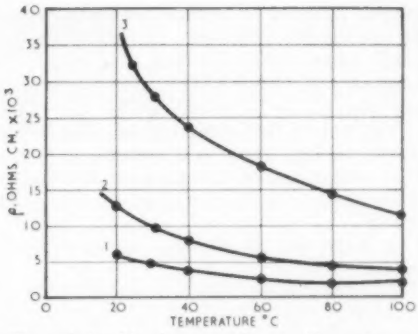


Fig. 5.—The relationship between the specific resistance of the anodizing electrolyte and temperature. The figures denote the compositions of the electrolytes, which are given in Table I.

especially in the instance where the circuit of Fig. 3 (b) is used.

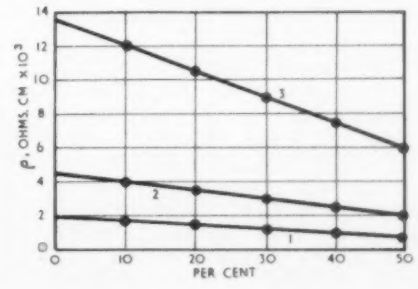
To what extent does the resistance of the foil change during the anodizing process ? Where the width of the strips which are drawn through the baths remains identical, the resistance of the foil depends essentially on the etching coefficient. Since this coefficient is not even stable within the limits of one coil, then under production conditions the strips drawn through each of the baths in accordance with Fig. 3 (a) may have very different etching coefficients, and this may become a serious cause of instability in the working conditions.

This cause is, however, entirely eliminated, if anodizing is conducted in accordance with the circuit of Fig. 3 (b) where the same length of foil is drawn through both the baths.

Three-Phase Continuous Anodizing

The simplest layout for feeding a three-phase continuous anodizing plant is shown in Fig. 7. The essential feature in this layout is that the

Fig. 6.—The relationship between the specific resistance of the anodizing electrolyte and the quantity of water evaporated. The figures denote the compositions of the electrolytes, which are given in Table I.



neutral point of the three-phase transformer must be isolated from the foil. If this is not done then single-phase anodizing will take place, the unsuitability of which in operation has been pointed out above.

The use of the layout for continuous anodizing shown in Fig. 7 makes it possible to :

1) obtain greater evenness in the loading of a three-phase transformer than by two-phase anodizing ;

2) make use of all three baths of an existing anodizing plant ;

3) ensure stable working conditions for dynamic anodizing, since the diagram in Fig. 7 is a development of Fig. 3 (b) for two-phase anodizing ;

4) ensure automatic anodizing by stages, in the same way as by anodizing in accordance with Fig. 3 (b) ;

5) make use of a single three-phase voltage sully, with identical tappings in each phase.

During three-phase dynamic anodizing the voltages between the foil and each of the baths rise from the first bath to the third ;

$$V_{I} < V_{II} < V_{III},$$

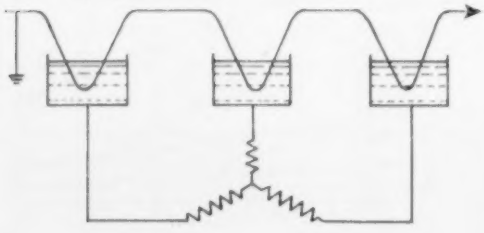
and the currents are correspondingly reduced :

$$I_{I} < I_{II} < I_{III}.$$

At the same time the proportion of the in-phase or active component in the full current on passing from the first bath to the third is reduced, and the portion of the reactive component rises. Fluctuations in the loading of the primary windings of the transformer from the balanced load, as experience has shown, are relatively small (about ± 20 per cent. in the individual phases).

During three-phase anodizing, as in the instance of two-phase, the greatest value of the coefficient of utilization of the anodizing currents is attained subject to the condition that the resistance of the foil greatly exceeds the resistance of the bath. This condition, as has been indicated above, may be ensured in plants of existing design by the use of materials from the baths which are not susceptible anodic attack.

Fig. 7.—Circuit diagram for three baths during three-phase dynamic anodizing.



Conclusions

1. Continuous anodizing of anode foil for electrolytic condensers with alternating current is more advantageous where differential circuit wiring diagrams are used.

2. The use of baths of existing design for anodizing with alternating current is possible where a material is used for their fabrication which is not susceptible to anodic attack (type 1Kh18N9T stainless steel for instance ; *see* page 105).

3. The greatest stability of the working conditions for anodizing is attained, where one and the same length of foil is drawn through baths connected together in a differential circuit (Fig. 3 (b)).

4. From the point of view of the loading of transformers great importance attaches to three-phase anodizing which, like two-phase, ensures the production of an anodic layer of high quality.

5. Continuous anodizing of anode foil with alternating current in baths connected by a differential circuit makes it possible to avoid the transformation of alternating current into direct current and the associated power losses, to avoid short circuits of the sources of supply when fractures of the foil occur, to improve the power factor (cos δ) for the plant, and to increase anodizing output, due to the prevention of polarization of the electrodes. All this ensures appreciable economic savings as a result of a change-over to this method of anodizing.

References

1. Zakgeim, L. N. and Nikolaeva, G. D., " Dynamic Anodizing of Aluminium for Electrolytic Condensers," *IEST*, 1938, (7), p. 57.
2. Renne, V. T., Electrical Condensers (Elektricheskie condensatory), *Gosenergoizdat*, 1952.
3. Zakgeim, L. N., Electrolytic Condensers (Elektroliticheskie condensatory), *Gosenergoizdat*, 1954.
4. Gunterschulze, A. and Betts, G., Electrolytic Condensers. (A translation was published in Russia by Oborongiz in 1938).
5. Lerner, M. M. and Odynets, L. L., Original Patent No. 110121, group 21 d 10/03.
6. Odynets, L. L., " Laws Governing Alternating Current Anodizing of Aluminium Anodes for Electrolytic Condensers," *Izv. vyssh. uchebn. zavedenii, Engergetika*, 1958, (7), p. 46.
7. Lerner, M. M., " Half Cycle " Anodizing of Aluminium Foil for Electrolytic Condensers at Various Relationships between the Surface Areas of the Specimen and of the Aluminium Bath." Theses of Report to the 8th Scientific and Technical Conference of VZEI, 1957.

" GAS IN INDUSTRY "

First Exhibition to be held in Provinces

AN exhibition under the above title, similar to that held recently at the Royal Horticultural Hall, London, will be held at the New Exhibition Hall, Harrogate, from March 28 to April 1. The exhibition will be organized by the North Eastern and Northern Gas Boards.

CRACK-FREE CHROMIUM PLATING*

by J. CORBIÈRE†

CRACKING of chromium electro-deposits is caused by high internal stress in the deposit, resulting from the co-deposition of hydrogen. The finest pattern of cracks is found in chromium deposits from baths which contain fluoboric acid or silico-fluorides as catalysts. Crack patterns from baths with mixed sulphate-fluoride catalysts are coarser and the usual sulphuric-acid/chromic-acid baths give the coarsest patterns of all. These cracks will obviously considerably decrease the corrosion protection of the deposit, for attack on the basis metal can take place through the wider cracks.

Furthermore, it is possible that traces of the plating solution are retained in the cracks, even after careful rinsing, while corrosion will be increased by electrolytic action between the chromium deposit and the basis metal. It has been said[1] however, that cracking of the chromium deposit will have no influence on its corrosion resistance because wetting of these deposits is very difficult and because it will be impossible for corrosive agents to enter the fine cracks. Against these arguments, it can be said that corrosion-producing media will be retained by capillary action in the cracks, while crack-free chromium deposits do in fact give very much improved corrosion resistance. Dettner[2] pointed out that improved corrosion resistance could also be due to other causes.

With chromium thicknesses of 20 microns to 30 microns, the crack pattern will, in general, be sufficiently fine to obtain satisfactory corrosion resistance under normal conditions. When chromium plating is employed for decorative purposes, a thickness of 0.3 microns is usually applied, because cracks will start forming at a thickness of 0.5 microns. Such very thin chromium deposits only prevent tarnishing of the underlying nickel deposit, and the corrosion resistance of the composite plate is, in fact, due to the nickel. Until recently, it was thought that the thin 0.3-micron chromium deposit did not improve the corrosion resistance at all, but it is now known that a very thin chromium deposit without cracks does improve corrosion resistance. The improvement to corrosion resistance is also due to the high degree of passivity of chromium to corrosion attack.

It is therefore unfortunate that increasing this very thin deposit of chromium leads to crack formation which reduces the protective value of the deposit. Some time ago, a method was developed in the United States[3] for closing these cracks by dipping the plated article in a bath of molten lead at 1,200°C. The thin layer of lead produced is stripped off afterwards with concentrated nitric acid. This results in the closing of the cracks with lead. A similar method was developed by Berghaus[4], [5] in Germany, using lead-aluminium mixed with iron and chrome instead.

Gebauer developed a method by which some of the cracks could be eliminated by recrystallization at high temperature. Eilender[6] however, could not reproduce these results. Also, treatments with paraffin or phosphating seemed to give no improvement. The author does not know of any current practical application of any method of closing cracks by any of these treatments.

With the exception of a few applications where porous chromium is specifically wanted—when hard chromium plating cylinders, for example—chromium deposits with pores or cracks are undesirable. In the literature, several methods are described for obtaining crack-free chrome deposits and much research is being carried out on this subject because of its great importance.

The crack pattern of the chromium deposit is caused by the internal stress of the deposit, as already mentioned. At higher temperatures, this stress is considerably higher, but as the tensile strength of the deposit increases to a much greater extent, crack-free deposits become possible.[7]

Most papers dealing with this subject mention, however, that crack-free chrome deposits have low internal stress.[8] In this paper, no further details will be given on the origin of the cracks which are influenced by solution temperatures, chromic-acid/catalyst ratio and the type or character of the base material. The type of catalyst which is used seems to have some influence, since self-regulating chromium solutions appear to give

* This paper was presented at the 3rd Biennial EFCO-Udylite Distributors' Conference held at Weybridge in Surrey from 7-9 October 1959.

† (Ets. R. Corbière).

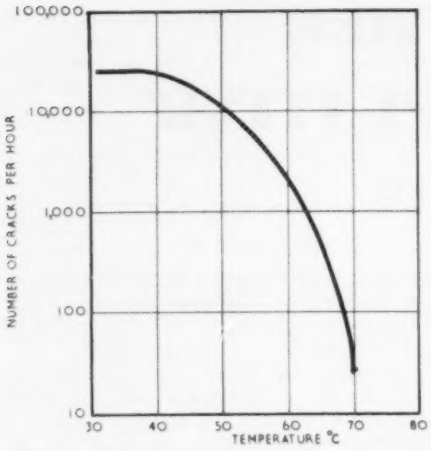


Fig. 1—Graphical representation of relationship between cracking and temperature in typical sulphuric-acid /chromic-acid solution (after Fry).

smoother, finer-grained deposits with fewer cracks.[9], [10]

An increase of the solution temperature will give chromium deposits practically free of cracks. A higher chromic-acid/catalyst ratio will improve the chances of obtaining crack-free chromium deposits. The higher tensile strength of chromium deposits at higher bath temperatures was also investigated by Eilender.[11]

The method of obtaining crack-free chromium by increase of bath temperature and sulphate ratio has been investigated by Brown.[12] This method, which has proved its value in practical plating, and which is known as *high-temperature/high-ratio* crack-free chromium, needs no further discussion here. A solution of 250 gm. per l. chromic acid with a ratio of 125 to 150 : 1 is used at 50 to 55°C. and deposits of at least 0.75 microns but preferably 1.25 microns to 2.0 microns are applied. To obtain sufficient brightness at this temperature, a current density of approximately 350 amp. per sq. ft. should be used. These conditions and an efficiency of approximately 13 per cent (this figure will be decreased by the high sulphate ratio) will give a deposit of 2 microns in about 6 min. The relation between cracks in chromium deposits and solution temperatures was also investigated by Fry of the British Non-Ferrous Metals Research Association.[13] Fig. 1 gives the relation between cracks and temperature in a normal sulphuric-acid/chromic-acid solution according to Fry.

The first announcement of crack-free chromium for practical plating in general and especially for self-regulating chromium solutions was given at the 14th Annual Meeting of the American Electroplaters' Society on June 16, 1953 by Dow and Stareck.[14], [15] In principle, this method is also based on the fact that high solution temperatures should be used (preferably 55°C.) and that the chromic acid-catalyst ratio should be greater than 100 : 1. A later patent of the Metal and Thermit Corp.[16] claims a complete crack-free chromium deposit obtained at higher temperatures and in a solution with a different ratio.

Crack-free chromium deposited from a self-regulating chromium solution has the following advantages :

1. The self-regulating solution will always work at the same optimum content of catalysing acid radicals.
2. Very little or no analytical control will be needed.
3. The solution will be less critical in view of the self-regulating properties.
4. The ability to cover nickel of the self-regulating solution is better than that of normal sulphuric acid chromium solutions.
5. The solution has a higher efficiency.
6. The self-regulating chromium solutions give a wider current density range for bright deposits.
7. Thicker deposits are obtained in less time.
8. It is possible to plate chromium over chromium : bad contacts will not interfere with the results.
9. Bright chromium plating of stainless steel is easier : the self-regulating chromium solutions also activate passive nickel deposits.
10. No iridescent films are produced.

Apart from two crack-free chromium solutions both based on the same principles of high temperature and high ratio, attempts were made to obtain crack-free chromium deposits from normal solutions by special additions. A patent of the Research Corporation, NewYork, [17] recommends the use of indium, and a patent of the British Non-Ferrous Metals Research Association[18] claims improvements by using selenium. The latter patent describes chromium plating in a solution of 250 gm. per l. chromic acid and 1 per cent sulphuric acid with and without additions of selenium.

With the addition of selenium, chromium deposits of up to 12 microns can be obtained without cracks : without selenium, cracks begin to form in deposits of a few microns. The tensile stress of the deposits which, without selenium, is 150,000 lb. per sq. in., is said to be decreased by the addition of selenium to a very much lower compressive stress of 10,000 lb. per sq. in.

The fact that an addition agent can be used to obtain crack-free chromium deposits made an

(*Continued in page* 111)

Crack-free Chromium Plating

(*Continued from page* 110)

investigation into this subject worth carrying out. In this investigation, the following solutions were studied :

1. Stareck self-regulating crack-free chromium.
2. High-temperature high-ratio crack-free chromium.
3. Novochrome at high temperatures.

Besides these three solutions, in which the freedom from cracks is due to high temperature and high ratio, a number of additions were tested both in the normal sulphruic acid and in the Novochrome solution in concentrations of 10 mg., 50 mg. and 500 mg. per l. Solutions 1, 2 and 3 were used at 55°C. and a current density of 350 amp. per sq. ft. for 6 min.

Both the sulphuric-acid chromium solutions and the Novochrome solutions in which the various products were tested were used at 45°C. and a current density of 150 amp. per sq. ft. for 14 min. To all solutions, Zeromist was added because, according to an earlier investigation, this fluoro-type spray-suppressing agent seems to have no influence on the formation of cracks.[19] The thickness of the chromium deposits obtained was 2.3 microns to 2.6 microns. All chromium deposits were on steel panels plated with approximately 14 microns of bright nickel from an Efco-Udylite 514 solution.

The cracks were shown up by using the test panel as a lid on an Erlemeyer flask in which concentrated nitric acid was kept at 70°C. Every hour, the test panels were studied and those with visible cracks were removed. The metals tested as to their influence on the chromium deposit were selenium, indium, molybdenum, vanadium, antimony, tin, cadmium, aluminium, thallium, lithium and tellurium.

Although the investigation is not yet completed, it was possible to reach the following conclusion :

(1) The Brown solution, the self-regulating Stareck solution and the self-regulating crack-free Novochrome solution all give very good crack-free deposits indeed. A study of the relative corrosion resistance of the deposits from these three solutions has not yet been made.

(2) During the investigation of the addition of various metals to the normal chromium bath, it was found that the composition of the solution itself had an influence upon the results.

(3) Out of a great number of best panels from the normal sulphate solution and from the Novochrome solution, both with the same metal additions, 112 panels showed no cracks after 1 hr. exposure to nitric acid vapour. Eighty-four of these panels had been plated in the normal Novochrome solution and 28 in normal sulphate chromium.

(4) In deposits from the normal Novochrome solution, the cracks which are present are smaller than in deposits from the normal sulphate solutions. Differences in the number of cracks and in corrosion resistance have not yet been investigated.

(5) Indium additions, which are patented and said to give crack-free chromium deposits, seemed to give no practical improvements in concentrations up to 500 mg. per l. The influence of higher concentrations have still to be studied.

(6) Selenium, also patented for the same purpose, has a favourable influence.

(7) A much stronger effect is obtained with additions of tin, aluminium, vanadium and molybdenum. The results of additions of tellurium, lithium and cadmium are dubious.

(8) Some metal additions such as selenium cause a change of crack pattern.

(9) Antimony seems to have an unfavourable influence upon the chromium deposits.

Much research has still to be done to open up this very interesting field.

References

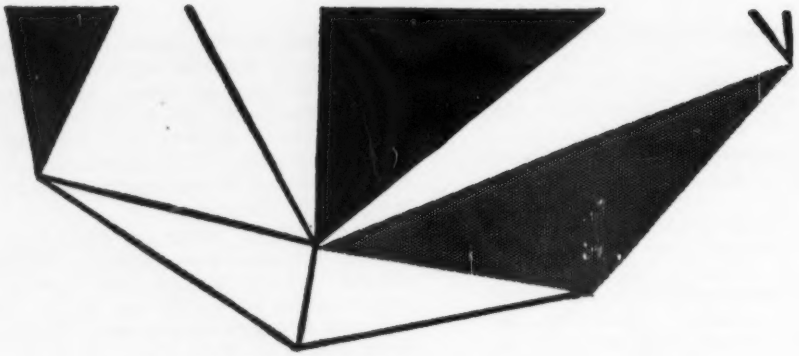
(1) Gebauer, *Korr. u. Metallsch.*, 1940, **16**, 297 Dettner.
(2) *Metalloberfläche*, 1950, **4**, pp. 33-37.
(3) U.S.P. 1, 606, 159.
(4) Germ. Pat. 698, 897.
(5) Germ. Pat. 709, 247.
(6) Eilender, *Metalloberfläche*, 1949, **3**, pp. 32-35.
(7) Brenner, *Proc. Am. Electropl. Soc.*, 1947, **34**, pp. 32-34.
(8) Dettner, *Metalloberflache*, 1950, **4**, pp. 33-37.
(9) Silman, *Metal Fin. J.*, 1955 (Jan.), p. 12.
(10) Stareck, *Proc. Am. Electropl. Soc.*, 1950, **37**, p. 31.
(11) Eilender, *Metalloberfläche*, 1948, **2**, p. 7.
(12) Brown, *Plating*, 1958 (Feb.), **45**,
(13) Fry, *Galvanotechnik*, 1955, **8**, p. 386.
(14) Stareck, *Plating*, 1953, **40**, pp. 987-996.
(15) DBP 1, 034, 445 : 1953.
(16) DBP 1, 044, 550 : 1955.
(17) U.S.P. 2, 630, 407.
(18) B.P. 798, 590.
(19) *Metal Fin. J.*, 1959, p. 97.

High-Temperature Corrosion

(*Continued from page* 101)

classified information of the Atomic Energy Commission seems to belie this fact. It is probable that a new realm of high-temperature corrosion problems is being entered.

High-temperature corrosion, then, is like conventional corrosion except that it involves direct chemical-compound formation instead of ion exchange. This minimizes the effect of hydrogen which is of primary importance in aqueous corrosion. But the same phenomena are encountered at high temperatures *i.e.* general attack ; localized pitting and catalytic effects at cracks and crevices; corrosion accelerated and localized by stresses, especially repetitive stresses leading to fatigue.



ALBRIGHT & WILSON

NICKEL SULPHAMATE

in nickel plating has special advantages

An electrolyte based on nickel sulphamate makes it possible to plate at very high current densities so that thick deposits can be produced in a short time. In addition the deposit has a very low internal stress and is particularly suitable for electro-forming applications where any distortion must be avoided. The deposits are also extremely ductile.

An example of this is in the production of distortion-free gramophone record stampers that can be rapidly electro-formed in the nickel sulphamate electrolyte. The ductility of the deposits from the nickel sulphamate solution increases the useful life of the stampers.

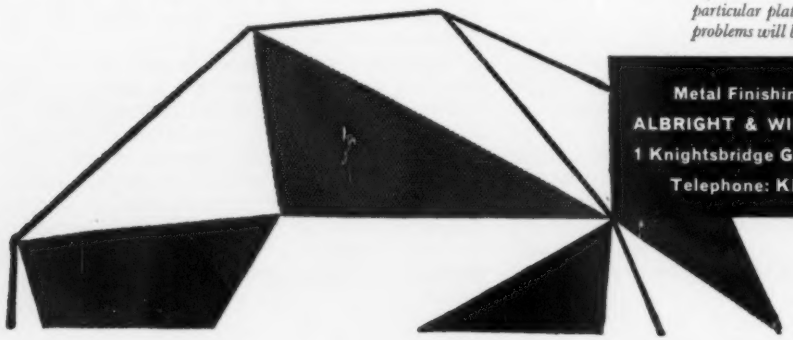
Another increasing use for nickel sulphamate is in the printing industry where it is used for facing stereos and electrotypes. The plating time is considerably reduced and the deposit is more homogeneous.

Nickel sulphamate electrolytes can be used for building up worn parts and also for decorative finishes, as the deposits are exceptionally easy to polish.

A detailed investigation of the properties of electrolytes based on nickel sulphamate has been carried out in Albright & Wilson's pilot plant in their Technical Service Department at Oldbury.

Albright & Wilson (Mfg) Ltd also supply Phosbrite chemical polishing solutions for copper and aluminium and their alloys, Plusbrite addition agents for bright nickel plating, together with chemicals for special processes in tin and copper plating and electrolytic polishing of ferrous metals.

Information and advice on your particular plating and polishing problems will be gladly given. Write to



Metal Finishing Department
ALBRIGHT & WILSON (MFG) LTD
1 Knightsbridge Green, London SW1
Telephone: KENsington 3422

FINISHING NEWS REVIEW

METAL FINISHERS TO MEET IN SCARBOROUGH

Grand Hotel Venue for April Conference

THE Institute of Metal Finishing Conference, held at Brighton last year, goes to Scarborough for the 1960 venue; the Conference is due to be held from April 26 to 30. The 1959 meeting was again a record in the number of full-time resident delegates, and it is hoped that a still larger attendance will be achieved at Scarboraugh where the Grand Hotel has been booked to provide every facility. A warm welcome has been extended to the Institute by the Mayor and Corporation of the town.

The technical programme of the conference, detailed below, caters for the greatest possible variety of interests within the industry, and there will be the usual opportunities for informal social contacts and discussions in addition to the more formal evening functions. A separate programme of entertainment for the benefit of ladies attending as guests of delegates has been arranged.

PROGRAMME

Tuesday, April 26. Grand Hotel

Evening—Registration and Informal Dinner.

Wednesday, April 27. Grand Hotel

9.30 a.m.—Official Opening of Conference.

followed by **1st Technical Session**

1 **"Review of Methods for Obtaining Improved Outdoor Corrosion Resistance with Nickel-Chromium Plate."** By H. Brown and D. R. Millage.

2 **"Factors Influencing the Corrosion Resistance of Decorative Plating on Zinc-Alloy Diecastings."** By O. Jones, V. E. Carter and J. Edwards.

1.00 p.m.—Luncheon.

Afternoon

2nd Technical Session

3 **"Sealing Anodic Oxide Films on Aluminium."** By G. C. Wood.

4 **"On the Assessment of Sealing of Anodic Oxide Films on Aluminium."** By T. P. Hoare and G. C. Wood.

5 **"The Growth Habit of Electrodeposited Copper."** By G. C. Storey and S. C. Barnes.

Grand Hotel

Evening—Reception and Dance by invitation of the Mayor and Corporation of Scarborough.

Thursday, April 28. Grand Hotel

Morning—**3rd Technical Session**

6 **"Throwing Power of Nickel Plating Solutions."** By S. A. Watson.

7 **"Solderability of Some Tin, Tin-Alloy and Other Metallic Coatings and the Effect on Them of Storage."** By C. J. Thwaites.

8 **"Detection of Zinc Diffusion into Tin Coatings on Brass."** By S. C. Britton and M. Clarke.

1.00 p.m.—Luncheon.

Friday, April 29. Grand Hotel.

4th Technical Session.

9 **"Studies on Surface Treatments of Aluminium and Zinc."** By D. B. Freeman and A. M. Triggle.

10 **"Lacquers for Outdoor Protection of Aluminium."** By A. W. Brace and R. E. M. Polfreman.

11 **"Technical Developments in the Application of Coated Steel Sheet."** By F. H. Smith and T. C. Tapp.

1.00 p.m.—Luncheon.

Afternoon —

5th Technical Session.

12 **"The Economic Advantages of a Sound Painting Scheme."** By U. R. Evans.

13 **"Water-thinned Coatings as Industrial Finishes."** By E. L. Farrow.

14 **"The Use of Vinyl Resins in Appliance Finishes."** By P. R. Day.

Grand Hotel

Evening — Reception by the President and Mrs. Harvey followed by Conference Dinner and Dance.

Saturday, April 30.

CONFERENCE CLOSES.

1.00 p.m.—Luncheon.

Conference Dinner and Dance.

The charge for the Conference dinner and dance is included in the full Conference charge. Members wishing to obtain additional tickets for this function in order to entertain guests should make the appropriate entry on the reservation form and include the necessary payment with their Conference remittance.

CELLON PAINT – AP LAB. AT

CELLON Ltd., Kingston-on-Thames, have recently expanded their paint-application laboratory and have installed much new equipment. The paint manufacturer must be in a position not only to produce formulae which will satisfy industry's needs but also, if possible, he should have facilities to test these formulations under conditions similar to those operating in the customer's factory. This, in fact, is the function of the Cellon laboratory which works in close liaison with the company's main research laboratory.

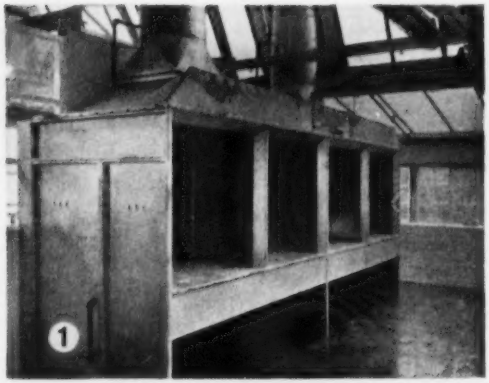
In addition to the practical testing of new finishes, the laboratory is used as a centre where customers can see demonstrations of new finishes or finishing systems and where they can evaluate new and improved methods of application. It also provides a department where articles sent in by customers can be treated ; it can provide specimen panels to customers' requirements etc.; new ideas and processes can be tested before being put forward for customer consideration ; and it acts as a training centre where customers' operators can be given instruction and where the company's own staff can be given basic training.

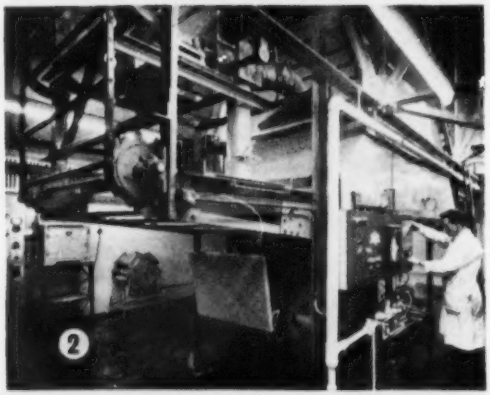
The new laboratory comprises four main sections, *viz.* wood finishes, metal finishes, screen and gravure printing inks and building and marine paints.

Metal Finishes Section

The spray room of the metal finishes section contains a dry back, four-compartment spray booth by Alfred Bullows and Sons Ltd., which by adjustment of the partitions, can be adapted for spraying very large objects should this be necessary.

There is, of course, the usual complement of spray guns and equipment and when hot spray application is required one of the mobile plants can be brought in from the wood finishes department. A specialized piece of apparatus of considerable interest is the airless spray plant supplied by T.C. Spray Finishing Systems Ltd. This plant enables specially formulated paints to be applied under pressure without the assistance of air at the gun nozzle. Heavy coatings can be sprayed over a





1. *Metal finishes section spray booths in course of erection.*
2. *Gas-fired camel-back oven.*
3. *General view of electrostatic room.*

(Right) Mr. J. Duncan Ferguson emphasises a point to Mr. J. Boyd Carpenter at the opening of the new Cellon laboratory

EXPAND PLICATION KINGSTON

Complete Department for Metal Finishes

wide area and this method is very satisfactory for the coating of really large metal components or machinery. For this reason it is mainly used with synthetic air drying finishes.

On one side of the metal-finishes spray room is the electrostatic room and on the other is the oven room. Both of these contain production size equipment.

ELECTROSTATIC ROOM

The electrostatic equipment is by Ransburg, supplied through their U.K. agents, Henry W. Peabody (Industrial, Ltd.; the conveyor is by Teleflex Products Ltd.

Briefly the theory of this method of paint application is to place the paint and the object to be sprayed in opposing fields of electric force so that the paint as soon as it leaves the issuing point is attracted to the object. Using this method the material wastage is virtually nil and where the electrostatic method can be adopted it is of considerable economic advantage in mass production. Specially formulated paints of known dielectric value have to be used and both paint and jig design are often individual to the job.

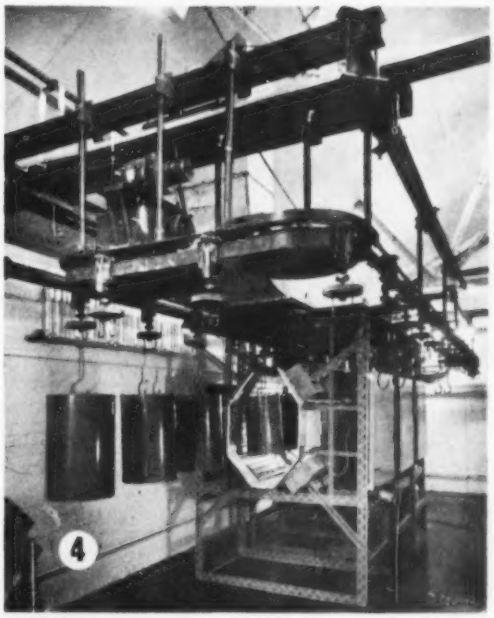
The electrostatic atomization is controlled from a switch panel so that the 90,000-volt electrostatic potential is applied to the paint as it leaves the rotating disc or bell and the charged particles earth themselves on the object suspended from the conveyor.

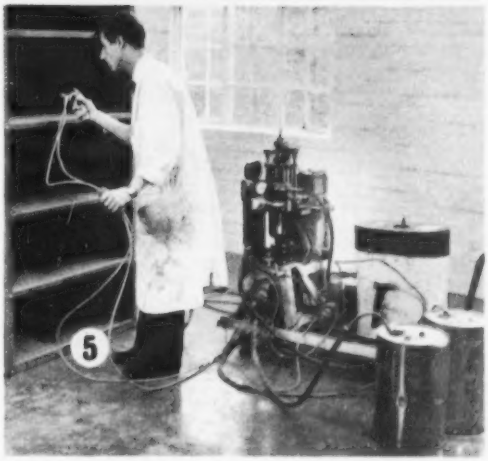
The equipment consists of a ceiling-mounted conveyor, running the length of the room, with a 5-ft. loop at one end. Objects suspended from the conveyor rotate from pre-determined angles so that electrostatic spraying can be carried out on shaped components such as refrigerators and washing machine bodies. In other words, each side is presented to the electrostatic unit for a predetermined time as the object moves around the loop. The conveyor speed is of a variable-control type so that speed of operation can be related to customers' conditions. The temperature in the electrostatic room is thermostatically controlled to reproduce operating conditions.

(i) *Bell:* Ransburg No. 2 triple head-bell unit, supplied by electrically operated paint pump. This type of equipment will be used in the main for sheets, pressings and castings where the jig design is of high importance.

(ii) *Disc:* Fixed position in the centre of the 5-ft. loop, Three sizes of disc are available so that the flow of paint can be related to the shape of the object travelling round the loop.

(iii) *Hand Gun:* This recently introduced piece of equipment is a mobile electrostatic unit which is fed by paint pump or pressure pot supply, and has its own transformer and voltage equipment so that it is freely mobile on the spray shop floor. It is of particular value in coating tubular metal furniture, open wire work, etc., where substantial paint savings can be effected.





4. *Electric infra-red oven.*

5. *Testing finishes through the airless spray plant.*

OVEN ROOM

The oven room equipment is capable of reproducing the majority of customers' stoving conditions and consists of the following ovens :—

(*Continued in page* 116)

V.E.D.C. INTRODUCE NEW LABEL FOR QUALITY VITREOUS ENAMEL

A NEW label has been introduced by the Vitreous Enamel Development Council for use on quality vitreous-enamelled surfaces and is available to any manufacturer who will agree that his enamelled surfaces conform to the general specification issued by the V.E.D.C.

The decision to issue the label is in conformity with a practice which is developing in the retail trade of applying a label to goods indicating that they have been tested and passed as meeting the standards of certain recognized associations and the necessity to advise buyers that the finish on an article is genuine vitreous enamel has arisen because the word enamel has, in the last few years, come to mean any glossy finished surface and is commonly used to describe paint.

The finish which is often termed "stoved enamel" is paint quick dried at a low temperature to produce a slightly harder surface. Physically it is entirely different to vitreous enamel which is a fused surface consisting of a thin layer of opaque glass, fired into the metal beneath at a very high tempeature.

Modern paints have a finish which, when new, is virtually identical in appearance with that of vitreous enamel, and manufacturers can mix the finishes on an article without there being a visible difference. This only applies to a new product in its showroom state and the difference between a vitreous and painted finish becomes more apparent when the article has been in use for some time. Unlike paint, vitreous-enamelled colours will not fade and it is far more resistant to acids, abrasion, rust, heat changes and general wear and tear than any painted surface.

Facsimile of V.E.D.C. label.

The advantages of paint over vitreous enamel are entirely with the manufacturer since it is easier to apply and offers fewer problems of design as it can be used on much sharper corners, edges, etc.

The purpose of this new label is therefore three-fold.

1. The label contains instructions on how to care for the enamelled surface so that the buyer will obtain the best possible service from the finish.

2. The label tells the purchasers something that is not easily ascertained by eye but which they should know. Paint is perfectly suitable for use on an article with a fairly short life or which does not have to withstand hard wear. Unfortunately its use is not restricted to this type of product and the label will enable consumers to judge if the finish can be expected to last as long as the article it covers.

3. The manufacturer is encouraged to use a longer lasting finish if the customer knows of its advantages and asks for it. If the buyer realises that such a finish is available they insist upon it and so obtain a much longer useful life from their purchases.

Although the label has only been available for a few weeks a number of well-known firms have already requested supplies and will be using the label on their products.

These include :

The Welsh Tinplate and Metal Stamping Co.
Curran Ltd.
Edward Curran Engineering Ltd.
National Enamels Ltd.
Enamelled Iron and Steel Products Co.
James Fellows and Son.
Economic Gas Boiler Co. Ltd.
Vitroflex Ltd.
English Electric Company Ltd.
Alexander Dunn Ltd.

The label will not appear on hollow-ware.

Cellon Laboratory

(*Continued from page* 115)

(i) Box oven: Barlow Whitney electric air-circulated convection oven.

(ii) Parkinson-Cowan gas-fired infra-red test unit.

(iii) Metropolitan-Vickers electric infra-red oven, with full electric control gear and energy regulators, so that variable stoving conditions can be set up on the plant. Each electric projector is on an adjustable arm so that the distance between the projector and the object can be varied. A lightweight Teleflex conveyor with variable-speed control is built in.

(iv) Ballard gas-fired camel-back oven. This oven, typical of the industrial installation, is conveyorized with flight bars so that maximum control and oven loading can be obtained, and the speed of stoving can be varied from about 15 minutes to 45 minutes. Temperature control is rapid over the whole range and stoving conditions from low temperature force-drying to at least 500°F. can be quickly achieved. The flight bar conveyor is arranged so that dip trials can be carried out and this type of oven is a most flexible unit over a wide range of stoving conditions. The oven is large enough to take a standard domestic refrigerator body.

It will be noted that the electrostatic room conveyor and the oven room conveyor are not directly connected. This isolation is deliberate because the development requirements on the electrostatic spraying are exacting and the application performance of paints on specific objects, particularly in respect of "throwing power" and coverage, must be carefully determined before stoving trials are carried out on the resultant formulation.

TECHNICAL BOOKSHELF

The Surface Treatment and Finishing of Aluminium and its Alloys by S. Wernick and R. Pinner. Second Edition, 1959. Robert Draper Ltd., Teddington. 607 pp. £4. 10s. 0d.

This book is well known as by far the most comprehensive review of the subject and, in view of the wide field covered, it is not surprising that some gaps or inaccuracies occurred in the first edition. It would seem reasonable to expect that a major object of producing a second edition, within three years of the first, would be to correct such omissions and errors and generally to profit from the experience of usage of the book, in addition to bringing it up to date. It is a little disappointing, therefore, to find such revision falling short of one's expectations, but the main disappointment can be avoided by skipping the first chapter.

The first two chapters of the first edition, which formed the introduction to the main subject, have been appropriately combined in one chapter, but the subject matter has not received the desirable improvement. The omission of the brief description of the standard alloys heightens the impression that this introduction lacks logic and balance, is too much concerned with academic details at the expense of broad principles of practical importance and is not up to date. For example, the section on super-purity aluminium makes only one mention of this purity and excludes it from the table specially given for this section, although an authoritative review of the metal was recently published (*Metallurgical Reviews*, 1947, **2** (8)). Again, the information on the corrosion of aluminium-magnesium alloys on pp. 16 and 21 is conflicting and inaccurate. The publications of the Aluminium Industry give much more lucid, accurate, practical information on the range of properties of aluminium and its alloys of interest to anyone concerned with the finishing of them, yet there is reference to only one of such publications and that in the Appendix.

It is quite a relief to proceed to the succeeding chapters, with their wealth of practical information and theoretical background, arranged in the same general pattern as in the first edition. Even here, however, there are some errors and omissions, examples of which may be given in the hope that the authors will consider this aspect more in the next edition. The writer regards nitric-acid cleaning, as generally used, to be a means of removing oxide and surface contamination, whereas the selective removal of alloying constituents or revelation of the crystalline structure of the metal, referred to on p. 156, is indicative of excessive treatment. The concentrations given for this acid are far in excess of those generally used for the purpose. More quantitative information might have been given on the opposing effects of the thickness of anodic films, on corrosion resistance and reflectivity respectively, especially in relation to metal composition. Fuller explanations of Figures 75 and 76 would make it less difficult to follow Baumann's and Schenk's theories on the mechanism of film growth in anodizing. Developments in conversion coatings are not adequately covered : for example, there is no mention of the Architectural Alocrom process, or of the ion-exchange resin plants developed for the regeneration of some conversion coating solutions. No mention is made of paint application by curtain coating. It is stated on p. 533 that priming paints " invariably " contain inhibitive pigments, yet red iron oxide is quoted by example in the same paragraph. While the references to the work of Rigg and Skerrey on priming paints are brought up to date, the text is not, and, in particular, still claims that the composition of the underlying metal is of little consequence when a full paint system is applied. It does not seem to be realized that " etch primers " (or pretreatment primers as they are more often called in this country) can suffer seriously from humid conditions or wetting after,as well as during, application, that low low temperature constitutes another hazard and that, while there are considerable variations in proprietary products, there are British products which adequately stand up to these severe conditions. Stoving is not essential to these products and, as the authors admit, they are frequently used on site. One might have expected that this book would include a reference to the improvement of the water-proofing to be attained by incorporation of leafing aluminium pigment in finishing coats.

The definition of a lacquer given on p. 533 is the traditional one, but the writer suggests, in view of the modern range of products, it would be more appropriate to divide unpigmented protective coatings into (a) varnishes — which dry by oxidation — and (b) lacquers — which dry by other means. Surely it is time that the curing of such coatings by polymerisation should be recognized.

The defects in the text referred to earlier call for some caution on the part of the reader, but the book remains a necessity for any organisation concerned with the surface finishing of aluminium and its alloys, while the revision which has been made certainly calls for the replacement of the first by the second edition.

F. A. CHAMPION.

Aluminium Busbar. A. G. Thomas B.Sc. (Eng.), and P. J. H. Rata B.Sc. (Eng.). London, 1960. Hutchinson Scientific and Technical for Northern Aluminium Co. Ltd. 105 pp. 21s.

This publication opens with a summary of the advantages in weight, cost, ease of handling, storage, transport and resistance to corrosion which aluminium as a material for busbar has over copper. This follows by chapters on the theories to be considered in the choice of type, size and shape of conductors for a.c. and d.c. applications having regard to thermal and mechanical requirements, the determination of the reactance of busbar assemblies and chapters on methods of calculating the forces to which busbar is subject in service and methods of bending, forming, jointing and connecting.

There are 18 Tables as an Appendix giving the characteristics of rectangular, channel and tubular busbars of various sizes and section areas, factors to be considered for temperatures and altitudes and varying indoor and outdoor assemblies, and types of fittings available for standard section busbars. A comprehensive bibliography is also included.

American Honing Machines Available in U.K.

THOMAS Mercer Ltd., dial and air gauge manufacturers of Eywood Road, St. Albans, have been appointed sole industrial distributors in the United Kingdom for the honing machines manufactured by the Sunnen Products Co., of 7910, Manchester Avenue, St. Louis, 17, Missouri, U.S.A.

Owing to import restrictions, these machines have not been available in this country for several years but, with this appointment, users of original Sunnen equipment will now be able to obtain supplies of Sunnen graded stones, a substantial stock of which will be held by the Agents.

TECHNICAL *and* INDUSTRIAL APPOINTMENTS

Cellon Ltd. announce the appointment of Wing Commander J. C. Cantrill to the board of directors.

As sales manager of the Cellon Aircraft Finishes Division, John Conway Cantrill is a well-known figure in the aircraft industry. He joined Cellon in 1930 after test flying for A. V. Roe. He served in the R.F.C. 1915-20 and in the R.A.F. 1939-1944 and holds the French Croix de Guerre.

* * *

William K. Whiteford, formerly of Toronto and now president of Gulf Oil Corp., Pittsburgh, has been elected a Member of the Advisory Committee of **The International Nickel Company of Canada, Ltd.,** according to an announcement by John F. Thompson, chairman of the board and Henry S. Wingate, president.

It is also announced that William C. Bolenius, executive vice-president of American Telephone and Telegraph Company, New York, has been elected a director of the company.

Mr. W. R. Todd

Mr. S. W. Vickery, the chairman of **Ferro Enamels Ltd.,** Wombourn, Wolverhampton, announces the appointment of Mr. W. R. Todd to the board of directors.

* * *

Borax Consolidated Ltd. have pleasure in announcing the appointment of Mr. G. N. Blow as their Midlands area manager in succession to the late Mr. D. G. B. Sleath. Mr. Blow has been with the company since 1953 as a local representative in the Birmingham area.

* * *

Mr. S. R. Finn, B.Sc., F.R.I.C., who has been elected chairman of the **Surface Coating Synthetic Resin Manufacturers' Association** for the fourth successive year, is chief chemist with **Blundell, Spence and Co. Ltd.,** in the company's Industrial Paints Division at Slough.

Mr. Finn joined Vulcan Products Ltd. in 1951. This company, with John J. Bowater Ltd. of West Bromwich, was recently integrated with the parent company, Blundell, Spence and Co. Ltd., of which it now forms the Industrial Paints Division.

* * *

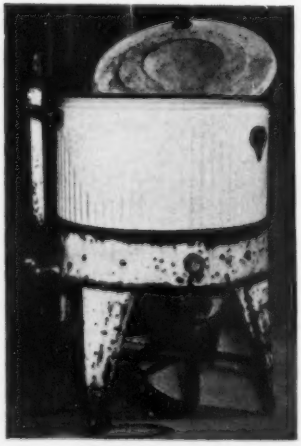
Cyril Houlton Neroutsos has become new president of the **Canadian Paint, Varnish and Lacquer Association** which represents 43 major paint manufacturers.

President of International Paints (Canada) Ltd., Mr. Neroutsos is well equipped to guide the association, having been in the industry for 35 years.

* * *

Mr. G. A. Hutcheson, M.Sc., A.M.I.Mech.E., has been elected an executive director of **NUMAS,** the advisory service set up by the National Union of Manufacturers to promote the application of modern management techniques in manufacturing industry.

Before joining NUMAS, Mr. Hutcheson held a senior appointment with Imperial Chemical Industries advising on the application of work study and related analytical methods to the planning and development of major capital programmes.



NEW COMPANIES

" Ltd " is understood, also " Private Co." Figures = Capital, Names = Directors, all unless otherwise indicated.

Brighthove Plating, 36 Foundry Street, Brighton, 1. January 8. £3,000. To carry on bus. of gold and silver platers, etc. Rupert C. Swann, Gordon Laraman, Flannan Houlihan.

Staybright Polishing, 111 Warstone Lane, Hockley, Birmingham, 18. January 12. £500. To take over the business of polishing of all types of metals carried on at Birmingham as " Staybright Polishing Company " by H. W. Hunt. Hugh W. Hunt, Mrs. Kathleen J. Hunt.

Timken. January 13. £100. To carry on the business of manufacturers of and dealers in tapered roller bearings, etc. Directors not named.

Brook-Blast, 28 Westminster Bridge Road, S.E.1. January 14. £5,000. To carry on business of contractors for the cleaning and preparation by blasting of metal and other surfaces in preparation for the application thereto of metal and other protective coatings, etc. Wm. J. Brooker, Donald M. Legget.

Somerville Laboratories, 27/29, Union Street, S.E.1. January 25. £100. To carry on the business of electroplaters, etc. Ivor Morgan, Thomas J. Spratt, Caroline S. Morgan Audrey E. Higgs.

Acme-Efco, Sheerwater, Woking, Surrey. January 29. £20,000. To carry on business of designers, manufacturers and operators of plant, machinery and apparatus for grinding, polishing and finishing metals, etc. Directors not named.

From the Register compiled by Jordan & Sons Ltd. 16 Chancery Lane, London, W.C.2.

VITREOUS ENAMEL SHOWS ITS ADVANTAGES

THE washing machine shown on the left has been in regular use for more than 20 years and is still used weekly to do the wash for a family of five. When new there was no apparent difference between the finish on the tub (vitreous enamel) and that on the base and lid (stoved enamel). Neither finish has been renewed since the machine was bought.

Corrosion Science Society Meets for First Time on April 4 and 5.

THE first meeting of the Corrosion Science Society will be held on April 4 to 5, 1960, at Battersea College of Technology, Battersea Park Road, London, by kind permission of the Principal, Dr. R. W. West, and the Head of the Department of Metallurgy, Dr. L. W. Derry.

The Provisional programme of fifteen talks in four sessions is as follows :

Session 1. *Monday, April* 4, 11 *a.m.*
Inauguration of the Society.
Election of Chairmen of Sessions.
N. F. Mott (Cambridge) : The interface between a metal and an electrolyte.
H. Nord (Copenhagen) : The role of hydrogen ion in the electrochemistry of iron.

Session 2. *Monday, April* 4, 2.15 *p.m.*
E. Mattson (Stockholm) : Stress-corrosion of brass against the background of potential-*p*H diagrams.
T. P. Hoar (Cambridge) and J. M. West (Sheffield) : Mechano-chemical anodic dissolution.
J. G. Hines (Billingham) : Electrochemical considerations in stress-corrosion cracking.
J. A. Whittaker (Fulmer) : Corrosion fatigue in aluminium alloys.

Session 3. *Tuesday, April* 5, 10 *a.m.*
E. C. Potter (London) : Corrosion in high-temperature aqueous systems.
C. Edeleanu and R. Littlewood (Hinxton) : Thermodynamics of corrosion in fused chlorides.
M. R. Achter (Washington) : Influence of oxidation on creep and cracking of aluminium.
J. L. Ll. Leach (London) : Some electrical properties of oxide films on metals.
R. A. Meussner (Washington) : The protective mechanism of a new coating for niobium.

Session 4. *Tuesday, April* 5, 2.15 *p.m.*
L. L. Shreir and E. Littauer (London) : The behaviour of lead containing a platinum micro-electrode when anodically polarized in chloride electrolytes.
T. P. Hoar (Cambridge) and T. W. Farrer (London) : The anodic behaviour of iron and steel in soil electrolytes.
J. E. O. Mayne (Cambridge) : New research in corrosion prevention.
J. A. Whittaker (Fulmer) : Atmospheric tests on aluminium alloys.
Discussion on next meeting.

There will be time for full discussion after each paper, and further discussion can take place on each evening among interested groups.

Coffee, lunch and tea will be provided at modest cost on each day, and there will be an informal dinner on the evening of Monday, April 4.

All scientists working in the field of corrosion and its prevention are welcome to attend.

A completed attendance form, obtainable from Dr. T. P. Hoar, with the appropriate remittance for meals and refreshments (*cheque made payable to Battersea College of Technology*), should be sent to him at, Department of Metallurgy, Pembroke Street, Cambridge.

S.C.E. Corrosion Group—Nominations for 1960/61 Committee

NOMINATIONS are invited for candidates to fill three vacancies on the Group Committee caused by retirements according to rule.

The retiring members, who have served for 3 consecutive years and are not eligible for re-election, are :—

Mr. L. B. Cotton
Dr. L. L. Shreir
Mr. T. Henry Turner
Dr. W. H. J. Vernon

Dr. S. G. Clarke retires from the position of Vice-Chairman to become an ordinary member of committee and there are thus three vacancies. Ordinary members of the Committe continuing in office are :—

Dr. C. Edeleanu, Dr. H. B. Footner, Mr. J. S. Gerrard, Dr. J. C. Hudson, Dr. F. Wormwell.

Prepared nomination forms will not be issued but nominations must be made in writing. Each statement of nomination must be signed by three members of the Group and must carry a declaration by the nominee of his willingness to serve if elected. If there are more nominations than vacancies, a ballot of members will be arranged.

Nominations should be sent to arrive not later than Thursday, March 24, 1960 to :

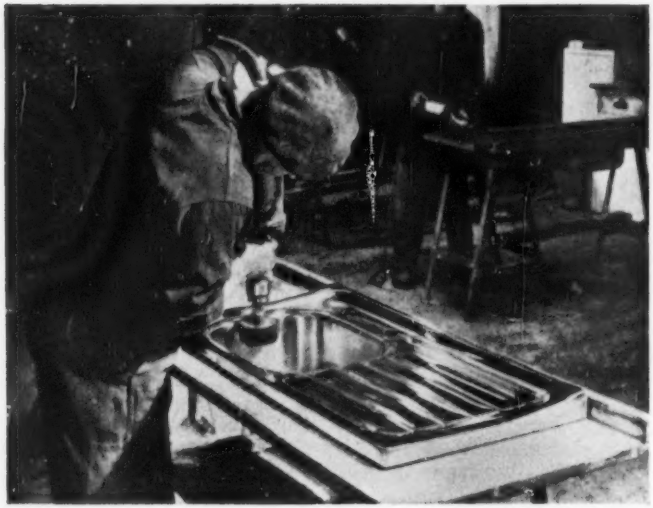
Mr. S. C. Britton, Hon. Secretary, Corrosion Group, c/o The Tin Research Institute, Fraser Road, Greenford, Middlesex.

CANNING "20" CLUB ANNUAL DINNER

AT the annual dinner held at the Head Office of W. Canning and Co. Ltd. recently, Sir Ernest Canning, president of the Club, enrolled 17 new members. On this occasion there were present 245 members of the Club which is for employees and former employees with 20 or more years service with the Company.

POLISHING at 'LEISURE'

Works Practice for Production of Kitchen Equipment



Typical polishing operation at Leisure Kitchen-Equipment

PRODUCTION at Leisure Kitchen Equipment's Long Eaton works is currently running at a high rate, a substantial output of stainless-steel and vitreous-enamelled-steel sinks and other fitments being produced in addition to a large volume of other kitchen furniture for domestic, hospital, catering and industrial use. While production consists of a very diversified range, significant features of manufacture are the extremely clean and orderly working conditions, the measures taken to obtain the maximum production from a given floor area and the quality-control philosophy which is concerned not only with the inspection of products for the most minute flaws but also with the prevention of the causes of defects before these develop.

The firm, which is a member of The Allied Ironfounders' Group, has recently brought into production a new press shop at Meadow Lane on a site close to the existing works at which the finishing and assembly work is concentrated. The Meadow Lane plant is accommodated on two floors, with the presses sited on the 1st floor. The stresses from these units are accommodated by mass reinforced concrete foundations, independent of the main structure, this being founded on bored concrete piles to a depth of 28 ft. below ground level.

Housed on this floor are all the major presses, which range in capacity from 1,100-ton hydraulic double-acting units to 350-ton mechanical presses. These are served by two overhead conveyor systems designed by the firm's engineering department and 10-ton overhead travelling cranes. The major conveyor which serves the presses and circuits the plant is 1/3rd mile in length while the secondary system, for handling the pressings through the degreasing plant, is 250 ft. in length. Degreasing is carried out after the first stage of pressing and is effected in a trichlorolthylene vapour chamber followed by a spray and drying. After degreasing, stainless-steel pressings are annealed at a temperature of 1,000°C. to overcome work hardening and are pickled in hydrofluoric acid solution, these operations being carried out in annexe to the main shop. On the ground floor are accommodated the machine tool room, in which all the press tools are made, the sheet-metal stores and the preliminary grinding section.

A certain amount of seam welding is carried out by continuous seam and stitch welding methods where bowls of non standard shapes require to be welded to the steel surrounding board. The preweld surfaces of the bowls are prepared for welding by Hicycle sanders in a shop adjacent to the annealing annexe, current being drawn from a A.E.I. 5-AW frequency changer. Two further A.E.I. 10-kW frequency changers serve the Hicycle polishers which are employed in the first stage polishing room on the ground floor.

At main works, the pressings for enamelling are taken successively through the shot-blasting plant and the grip-coat dip baths. After firing of the first coat, the colour coats are fused in a 1350-kW continuous furnace. The stainless-steel pressings are polished in a number of stages using Consolidated Pneumatic Hicycle, high-frequency electric sanders and buffers, a total of some 130 of these tools being in use throughout the works, over 90 of these being used in the polishing shop. The most generally used model is the 401G-5000 buffer with 6-in. diameter mops. These tools are operating from a 200-cycle 3-phase circuit at 125 volts, or to earth 72 volts. A claimed characteristic of the induction motor is a speed slip between free loaded conditions of only 10 per cent. as compared with the 50 per cent. slip of a universal motor and a speed drop of 25 to 30 per cent. of a compressed-air motor. This characteristic, apart from such aspects as a higher rate of metal removal, ease of handling and economy in power consumption, is responsible for the high, constant spindle speeds which are necessary to obtain a deep polish.

A point of interest is that 6-in. diameter mops are used with the 401G-5000 Hicycle grinders. The machine was specially developed to give this speed for polishing of stainless steel where 6-in. mops are preferred. This speed has been most satisfactory and is preferable to the standard 6000 r.p.m. which is too fast and is liable to cause a heat discolouration on the metal.

The sequence of polishing starts with the use of calico mops dressed with 80-grit Aloxite, this being followed by further mops dressed with finer grips down to 180 bauxilite. Felt wheels, lubricated with bobbing grease and dressed with 140 grit emery are then employed, followed in turn by calico mops dressed with 240 grit emery. The final stages employ brushes in conjunction with various types of fine polishing media.

Trade and Technical Publications

In the January issue of "Pretreatment News" published by I.C.I. Ltd., reference is made to the use of "Granodine" and "Alocrom" in degreasing and pretreatment of metals prior to painting in the production of Gestetner duplicators.

At their Tottenham works, Gestetner Ltd., use a double system of treatment with Granodine and Alocrom in one installation so that the pretreatment lines can be kept to one side of the floor space, clear of the painting operation. The whole process of degreasing, washing, pretreatment and drying takes half an hour from the point of loading on the conveyor to the point of unloading.

Reference is also made in this issue to the pretreatment of washing machine components by Burco Ltd., Burnley. Granodine and Alocrom are also used, prior to electrostatic painting.

* * *

Bakelite Ltd., 12-18, Grosvenor Gardens, London, S.W.1., have issued a booklet on the general characteristics of epoxide resins and their applications. The following is a list of some of the applications in tool manufacture where epoxide resins have been used successfully: press tools for sheet-metal forming; drop-hammer tools; jigs and fixtures; foundry patterns; models of all types and surface coatings including paints.

* * *

"News" No. P16 issued by the Cambridge Instrument Co. Ltd. 13, Grosvenor Place, London, S.W.1, refers to the use of special thermocouples for measuring the temperature of pipes. By attaching the thermocouples to pipe systems at intervals and connecting each one to a permanent or portable multi-point indicator it is possible to obtain a direct reading from the heating source of each room or point from which a reading is required.

* * *

"Australuco News," November-December, 1949, issued by Australian Aluminium Co. Ltd., Granville, New South Wales, deals mainly with the use of aluminium in the form of curtain walling in the construction of new buildings. An editorial refers to the advance in the use of porcelain-enamelled aluminium in the U.S.A., which has doubled every year for the past three of four years and expresses the hope that once architects and architectural manufacturers in Australia have confidence in this new surface treatment with its vast range of maintenance-free colours, this trend will be repeated in Australia.

"Wiggin Nickel Alloys" No. 54, the technical journal of Henry Wiggin and Co. Ltd., Wiggin Street, Birmingham, 6, contains articles dealing with the properties and possible applications of high nickel alloys.

Monel nickel-copper alloy is widely used in sea-water evaporators and filters because of its resistance to corrosion, and nickel-chromium alloys in the construction of furnaces, boilers, etc., because of their high heat resistance.

For many years, the standard method of working nickel-chromium alloys has been by extrusion and a problem has arisen when using steel dies in that there is a great tendency for the dies to wash-in at the throat, necessitating a grinding operation after each extrusion. It has been found that when Nimonic 90 nickel-chromium alloy is used as a die material, the tendency to wash-in is reduced considerably.

* * *

"Cobalt," No. 5, December, 1959, a quarterly journal published by Centre D'Information Du Cobalt, Brussels, contains a comprehensive article, together with tables, on the corrosion resistance of some stainless steels alloyed with cobalt, a detailed article on the machining of cobalt-containing alloys and also a review on the behaviour of permanent magnets at high temperatures.

* * *

"EDA Electrified Production," No. 3, 1959, published by the Electrical Development Association, 2, Savoy Hill, London, W.C.2., deals mainly with electric furnaces for the production of iron and steel and vitreous enamelling. Some details are given of two vitreous-enamelling furnaces, supplied by Ferro Enamels Ltd., the first, rated at 1,320 kW, in installed in the works of Leisure Kitchen Equipment Ltd., and the second, rated at 200 kW, in the works of the Tipton Enamel Co. Ltd., where it is used for firing fluorescent trough reflectors.

Reference is also made to a new EDA film in colour "Industrial Electric Heating" which, together with other industrial films can be obtained on free loan from EDA in 16- and 35-mm. sizes.

* * *

Brochures have been received from the Magnus Chemical Company Ltd., Salisbury Road Industrial Estate, Uxbridge, Middlesex, illustrating machines and spraying equipment produced by them for the industrial cleaning and degreasing of metal. The Miji-Lif washing machine has a working capacity of 30 gallons but Aja-Lif machines are available for cleaning work weighing up to a ton per load.

Where it is impracticable to strip down heavy plant and machinery for cleaning, the problem can be solved by spraying Magnusol over the surface followed by pressure rinsing with water. Magnus Alt[illegible]-H is specially prepared for [illegible]e cleaning and etching of alumin[illegible].

Another product of Magnus Chemical Co. Ltd., is Protectoline for protecting machined surfaces prior to packing and storage. It can also be used to prevent oxide formation on brass, copper, aluminium, steel and cast iron as well as rubber and glass moulds.

* * *

Application Sheets on the subject of pH have recently been compiled by W. G. Pye and Co. Ltd., Granta Works, Cambridge. The sheets now available are given as follows:

pH/1	The Measurement and Control of Boiler Condensate Return Water
pH/2	The Significance of pH in the Treatment of Boiler Feedwater in High Pressure Boilers
pH/3	The Aspect of pH in Water Supply Treatment
pH/4	pH in Nickel Plating Solutions
pH/5	Chrome and Cyanide Effluent Treatment
pH/6	pH Control in Ore Flotation
pH/7	The Importance of pH Control in Phosphate Chemistry
pH/9	The Effect of pH in the Chlorination of Wool to Produce Shrink Resistance
pH/10	The Determination of Chlorides in Aqueous Paper Extracts using a pH Meter
TI/1	Automatic Sulphur Determination

Application Sheets are supplied free of charge upon request.

(*Continued in page* 122)

MEETINGS OF THE MONTH

March 16

Society of Instrument Technology (London Section). "The simulation of a large chemical plant on an electronic analogue computer," by A. H. Doveton and K. C. W. Pedder, at Manson House, 26 Portland Place, London, W.1. 7 p.m.

March 17

Institute of Vitreous Enamellers (Northern Section). "Corrosion resistance of vitreous enamel for domestic appliances," by N. S. C. Millar at the Old Nags Head, Deansgate, Manchester. 7.30 p.m.

Institute of Vitreous Enamellers (Midland Section). "Possibilities of Direct Process Enamelling on Sheet Steel," by S. E. A. Ryder and J. Semple, and Section Annual General Meeting, at the Birmingham Exchange and Engineering Centre. 7.30 p.m.

March 21

Institute of Metal Finishing (London Branch). "Electroforming Nickel Screens" by Dr. L. G. M. Teepe, at the Northampton Polytechnic, St. John Street, E.C.1. 6.15 p.m.

March 25

Institute of Metal Finishing (Sheffield and N.E. Branch). "Heating and Filtration in the Plating Industry," by H. Cann, at the Grand Hotel, Sheffield. 7 p.m.

March 29

Sheffield Metallurgical Association. "Corrosion — the £600 Million Problem," by A. M. Edwards, at BISRA Laboratories, Hoyle Street, Sheffield 3. 7 p.m.

March 29-31

Institution of Chemical Engineers (North Western Branch). Symposium on Chemical Process Hazards with special reference to plant design. Details to be announced.

April 5

Institution of Plant Engineers (Peterborough Branch). "The design and use of the air compressor in the chemical industry," by J. Wholley (Peter Brotherhood Ltd.), at the White Lion Hotel, Church Street, Peterborough. 7.30 p.m.

April 6

Society of Chemical Industry (Corrosion Group). "The Presentation of Corrosion Information" by J. W. Jenkin, at 14, Belgrave Square, S.W.1. 6.0 p.m.

April 11

Institute of Metal Finishing (London Branch). "Stress Measurements," contributed by three authors, at Northampton Polytechnic, St. John Street, E.C.1. 6.15 p.m.

April 12

Society of Chemical Industry (Oils and Fats Group). Annual general meeting, in the Small Lecture Theatre, Donnan Laboratories, University of Liverpool. 6.30 p.m.

April 14

Institution of Plant Engineers (North East Branch). "Some applications of plastics in industry," at Roadway House, Oxford Street, Newcastle-upon-Tyne. 7 p.m.

Trade and Technical Publications

(*Continued from page* 121)

The "Inco-Mond Magazine" No. 12, issued by The Mond Nickel Co. Ltd., Thames House, Millbank, S.W.1., contains 35 pages, all of which are of interest to those concerned in the use of high-grade nickel alloys and stainless steel. Principal articles refer to the new foundry at Crewkerne for the Cronite Foundry Co. Ltd., the architectural uses of stainless steel in America and Europe, the building of an all 18/8 stainless-steel plant for cream and dried milk for Cow and Gate Ltd., at Lostwithiel and the use of 18/8 stainless steel in the "Barnes" system of pasteurising and sterile racking of beer.

A reference is also made to the use of solid rhodium contacts in a new device which makes it possible to transmit facsimiles of documents by telephone.

* * *

"Teleflex International News" issued by Teleflex Products Ltd., Basildon, Essex, gives in the January issue several articles describing how their range of conveyors assist in production lines and also in the internal transport of goods and products in confined areas.

A particularly interesting development is the use of industrial actuators to control heavy loads from a distance. The actuator is an electro-mechanical device with a straight-line thrust of 3,000 lb. over a stroke of 12 in. It can stop instantly and hold a load even when electric power has failed.

The actuator is adaptable for use in automation and other spheres and it is already being used to operate boiler controls, large butterfly and plug cock valves, etc.

* * *

The Metals Division of Imperial Chemical Industries Ltd., have now published "I.C.I. Titanium" No. 3 giving tables rating the resistance of titanium to corrosion by chemical reagents, industrial liquors and liquid metals. Titanium has a proved resistance to a wide range of aggressive media and in many instances is superior in this respect to stainless steel.

* * *

Publication 501 from A.E.I.-Birlec Ltd., Erdington, Brimingham 24, gives details and illustrations of their G.P. 1000 and G.P. 1400 furnaces for temperatures up to 1,000°C. and 1400°C. respectively. These are electric box-type furnaces and some of the processes for which they are usedare ; hardening, carburizing, preheating, annealing, normalizing stress relieving, brazing, vitreous enamelling and ceramic glazing.

* * *

"Roto-Finish Record" for January, 1960 published by Roto-Finish Ltd., 39, Park Street, London, W.1., includes an interesting article on the advantages and development of vibratory action machines instead of the conventional rotary action system used in the mechanical finishing of metal and plastic components.

Attention is also drawn to the orders received for large electro-polishing installations as an indication of the trend for these installations to take the place of the conventional polishing shop where manual operations provide a bottleneck.

The issue also deals with Grisiron 40, a new formulation in additives to water wash for cleaning out paint spray booths.

* * *

Metalelectric Furnaces Ltd., Cornwall Road, Smethwick, Staffs., have issued a new leaflet No. M4b. entitled "Standard Box Type Furnaces." The furnaces have been developed for a wide range of heat treatment processes and basically for operating temperatures up to 1,000°C. Mild-sheet steel has been used for the outer casing which encloses the door mechanism and the hearth plate is cast from a special nickel-chromium alloy. Instrumentation and control equipment is incorporated in a separate cabinet.

Latest Developments in PLANT, PROCESSES AND EQUIPMENT

Strippable Coating for Spray Booths

UNLESS spray booths have side water walls as well as the normal rear water wall, it is virtually impossible to keep overspray from building up where it is not wanted. Even with semi-automatic spraying when the amount of paint or sprayed material is carefully regulated to prevent waste, some paint will adhere to the inside of the booth.

Now Aerostyle Ltd. market a rubbery material which can be sprayed or brushed on to the sheet-metal work, laid on slightly more thickly than a normal coat of paint. When the booth is cleaned, all that is necessary is to scrape up one corner and strip off the coat which comes away in one piece with the overspray paint.

Further details are available from Aerostyle Ltd., Sunbeam Road, North Acton, N.W.10.

Paint Spray Pump

A PROBLEM frequently met in spray finishing is that of feeding to the spray gun a material which is heavily pigmented, and which readily settles out when not being used.

Almost every manufacturer who is spraying filler as part of his finishing process is familiar with the difficulties which can be encountered after work has been interrupted for only a few minutes. The material, after leaving the pressure container, may settle out in the hose, and spraying cannot be resumed without considerable waste of time and filler.

Alfred Bullows and Sons Ltd. now claim to offer a simple solution. The Bullows "Pogo" pump (Fig. 1) is used to feed the material through a standard fluid hose to the spray gun, to which is attached a "Y" piece. From the "Y" piece a second length of hose provides a return flow to the pump and hence to the container of material, which is itself kept agitated by this constant flow and return of material. This very simple arrangement has now been operating in the manufacturer's works for just over 18 months, running day and night, and it is possible to pick up the gun and spray filler at any time, without any stoppage at all. The pump will pump from a mixing or storage tank, or can even be mounted on the existing pressure feed container if this is preferred.

Fig. 1.—The Bullows "Pogo" pump

The equipment operates off the existing air line, using less than 3 cu. ft. per min. of air at pressures as low as 30 lb. per sq. in.

The immediate application for this new development will be in the machine-tool industry and similar trades where finishing of castings is carried out on a large scale. Since many machine-tool finishers use a metallic paint, the same technique can be used to overcome its properties of settling out, so that the new equipment will meet a need in many existing paint shops.

Further details of the " Pogo " pump are available from Alfred Bullows and Sons Ltd., Long Street, Walsall, Staffs.

Duplex Plating Process

A NEW addition to the rapidly growing range of metal-finishing interests held by Albright and Wilson (Mfg.) Ltd., is a duplex plating process that should be of considerable value to the automobile and allied industries.

The new process is a development of the original Plusbrite process, and is designed to give maximum corrosion resistance together with a fully-bright plate, for such applications as motor-car trim and similar automobile accessories.

A new additive is used, Plusbrite S.F., which is a sulphur-free addition agent and when added to the plating bath produces an electrolyte giving a semi-bright deposit, it is claimed, of high ductility and low internal tensile stress with excellent levelling properties. The deposit has a columnar structure. The standard Plusbrite solution is then used to produce a fully bright finish. As the second deposit is lamellar in structure, a very high standard of corrosion resistance is attained by the duplex process.

Full information is available from the Metal Finishing Department, Albright and Wilson (Mfg.) Ltd., 1, Knightsbridge Green, London, S.W.1.

Water Treatment Plants

MANY manufacturing processes involve the use of comparatively small but readily available supplies of high-quality demineralized water. To enable manufacturers to produce their own requirements, from ordinary mains water, The Permutit Co. Ltd., London, are making Panel Type Mixed Bed " Deminrolit " plants (Fig. 2) which use neither heat nor power during operation thus obviating the disadvantages attendant on distillation; running costs are much lower, it is said, than the purchase of special quality distilled water.

The plants are available with 6-in. diameter and 9-in. diameter cylinders and are self-contained free-standing units. An enamelled steel cabinet houses the single vertical cylinder which contains intimately mixed cation and anion exchange resins. Mains water, in passing through the cylinder, is subjected

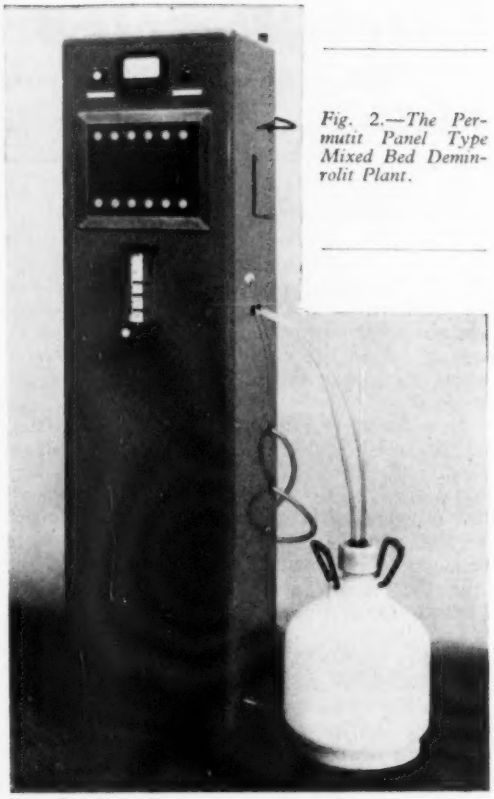


Fig. 2.—The Permutit Panel Type Mixed Bed Demnrolit Plant.

to an almost infinite number of alternating cation and anion exchanges. The result is a water demineralized to a high degree of purity with a conductivity of less than 1 reciprocal megohms per cu. cm. During the major part of the operational run between regenerations water with a conductivity of between 0.2 and 0.5 reciprocal megohms per cu. cm. is obtained.

Each plant is equipped with a built-in multi-valve control panel, a conductivity tester, motorized air blower and flexible connexion and delivery tubes of polythene material. A polythene bottle for holding chemical regenerant solutions is provided; this normally stands on the floor alongside the plant.

The air blower provides pressure for injecting regenerants into the mixed-bed cylinder and the air stream necessary for re-mixing the resins after regeneration. The conductivity tester provides a continuous check on the quality of the water being produced ; it thus indicates when regeneration becomes due.

Both sizes of plant occupy a cabinet measuring overall approximately 6 ft. high by 1 ft. 8 in. wide

while installation involves simple connexions only to the raw water supply, to service and to drain. The ion-exchange resins used are polystyrene spherical beads manufactured by Permutit, a special feature of these resins being their extreme robustness and durability. Diluted commercial hydrochloric acid and diluted caustic-soda solution are required for regeneration, these solutions being prepared and placed in the polythene bottle when required.

The total output of demineralized water between regenerations varies with the quality of mains water but flow rates of up to 60 gallons hourly for the 6-in. diameter and up to 135 gallons hourly for the 9-in. diameter plants are normally obtainable.

Wire Spraying Equipment

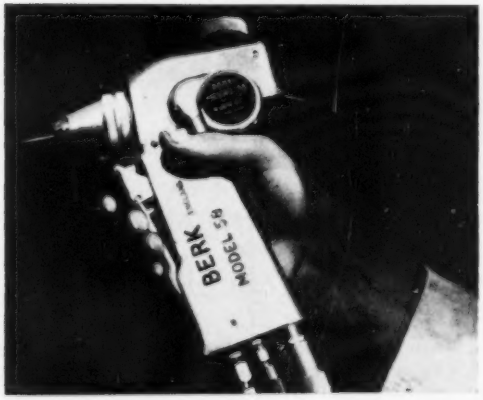
NEWLY introduced by F. W. Berk and Co. Ltd., Schori Division, Brent Crescent, North Circular Road, N.W.10, is a wire-spraying equipment known as the Model 58 Wire Gun (Fig. 3), in which a powerful air motor with infinitely-variable speed control is incorporated as a remote unit so that there is no weight to the operator.

The pistol is fitted with a hand-grip which, when depressed, operates the gas and air valves and starts the air motor which feeds the wire through the pistol. On releasing the grip the wire is stopped and the main gas and air supplies are shut off leaving a small pilot flame so that the operator only has to depress and release the hand-grip to stop and start the spraying operation.

The fuel gas, oxygen and compressed air can be conveyed to the pistol direct from the main supplies. Alternatively, they can be fed through a specially designed control panel mounted on a light tubular trolley which also accommodates the flow-meter, wire reel stand and the air motor with variable-speed drive.

Since the air motor and variable-speed drive are located away from the pistol their weight is unimportant and it has been possible to use heavy-duty equipment which gives reliable and constant wire through-put at any required speed.

Fig. 3.—Schori Model 58 Wire Gun



Balance

THE first of the new series of balances designed for general purposes but incorporating analytical features, has been produced by Griffin & George Ltd., Ealing Road, Alperton, Wembley, Middlesex, England. Called the Griffin *Minor* balance, it has a short beam for speedier weighing; single-limb bows carrying the weighing pans for unimpaired operation; an inclined scale which rises with the pointer, thus facilitating reading and avoiding parallax ; a unique design in stirrups to protect knife edges; and a new design pillar allowing easy and rapid assembly.

The improved assembly of the agate bearings is extremely important because they are held in position by positioning screws instead of being "drifted in" which is the usual practice. When the beam is arrested all the agate bearings are relieved, giving a long life.

The balance has a short beam and the poising nuts are near the central agate, where they cannot so readily contribute to accidental displacement of the beam and are not so easily damaged. This arrangement greatly reduces the overall length. While the balance is not in use the beam is located by two central slots in the arrestment beam, and kept horizontal by two locked screws. These slots are deep enough to prevent the beam being accidentally dismounted and accurately guide the beam during assembly of the balance. The stirrups are single-piece pressed-metal type with double hook, and, when the beam is in the "rest" position, are lifted clear of the end knife edges by the integral Y-arms of the arrestment beam.

The twin pillars which support the arrestment beam are mounted on a rectangular plate, held in position by two nuts positively located beneath the base. Between the pillars passes a plated rod which carries the central bearing plane, the scale, and the cam-plate. The use of the rectangular, slotted cam-plate, fitting directly on to the crank-pin, elininates the need for a connecting rod.

The pointer, which carries an easily-adjustable sensitivity weight, has an obliquely cut tip. This moves over a curved, inclined scale which rises with the beam, permitting comfortable reading without parallax. Such an arrangement facilitates more accurate observation of oscillations.

The form of bow adopted ensures that loading is completely unimpeded, a point of particular importance when the balance is used with a specific-gravity stool. An adjustable grub-screw in a lug on the base of each bow prevents the pan swinging when the balance is arrested. The price of this equipment is well below £10.

Classified Advertisements

Prepaid rates: FIFTEEN WORDS for 7s 6d. (minimum charge) and 4d. per word thereafter, or 24s. per inch. Box number 2s. 6d., including postage of replies.

SITUATIONS VACANT

METAL-FINISHING ORGANISATION specialising in chemical surface treatment requires

(1) experienced **CHEMIST** preference given to applicant with experience in the PRE-treatment of metals, and practical as well as theoretical knowledge is required

(2) Plant specialist experienced in automatic plant cleaning, phosphating, de-rusting, plating, etc.

Write in confidence stating experience in Chronological Order, age and indicating salary required. Box 224 METAL FINISHING JOURNAL.

MACHINERY WANTED

I.C.I. POPULAR DEGREASER wanted (Larger Models considered) Preferably gas heated. Must be in good condition. Offers to Fisco Limited, 602, Seven Sisters Road, South Tottenham, N.15.

L I L

LAPORTE TITANIUM LIMITED

(a member of the Laporte Group of Companies)

Have a vacancy in their New Research Laboratory, near Grimsby, for a

CHEMIST

with experience in the

CERAMIC INDUSTRY

The work will be concerned mainly with the

applications of Titanium dioxide in vitreous enamels and glazes.

Usual Company amenities, and salary in accordance with age, qualifications and experience.

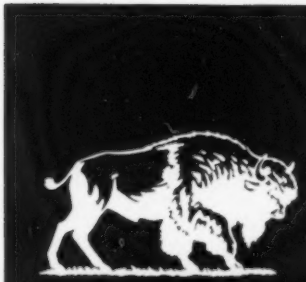
Applications giving details of age, qualifications and experience, and quoting ref. LTS/MF1/16 should be addressed to The Group Personnel Manager, LAPORTE INDUSTRIES LIMITED, Hanover House, 14 Hanover Square, London, W.1.

You mean you plan and install COMPLETE Paint Shops!

Mr. Brown thought paint shop planning required negotiating with several firms to supply all the various equipment, another to plan the lay-out, and a separate concern to under, take installation. When we assured him Volspray Limited did the lot, he was noticeably enthusiastic, "That's convenient. And it must reduce time and cost too," he hinted. How right he was! *Your* finishing department can also benefit from Volspray's "all-in-one" planning. Call us in — *now*.

VOLSPRAY LTD. 122-5 Grosvenor Gardens House, London, S.W.1. Tel.: VICtoria 2974/5

For all spray painting equipment



BUFFALO BRAND

BORAX

•

BORIC ACID

•

SODIUM SILICOFLUORIDE

Immediate delivery from U.K. stocks from

CLIFFORD CHRISTOPHERSON
& CO. LTD
An Associate Company of Albright & Wilson Ltd.

LONDON
1 Knightsbridge Green, London, SW1
Tel: Kensington 3422

MANCHESTER
127 Royal Exchange, Manchester 2
Tel: Deansgate 4789

GLASGOW
75 St. George's Place, Glasgow, C2
Tel: Central 5440

LEEDS
69 Cabinet Chambers, Basinghall St, Leeds 1
Tel: Leeds 22180

BIRMINGHAM
Union Chambers, 63 Temple Row, Birmingham 2
Tel: Midland 7705

YAW/473

INTRODUCING TO ALL ANODISERS MAGNUS ALTRETE H

THIS NEW ADDITION TO THE MAGNUS RANGE OF METAL FINISHING CLEANERS GIVES YOU

★ *FAST SATIN-SMOOTH ETCHING*
★ *COMPLETELY STREAK FREE SURFACES*
★ *CONTINUOUSLY CLEAN TANKS*
★ *SAVINGS IN TANK CLEANING*
★ *REDUCTIONS IN HEATING COSTS*

Write or telephone for a trial quantity and prove these important advantages for yourself

Magnus Chemical Company Ltd.

Industrial Estate, Uxbridge, Middx.
178, Bristol Road, Birmingham, 5

Uxbridge 6278
Calthorpe 1201

Aircool BIAS BUFFS

If you wish to consult us about reducing your buffing costs write or phone and a technical representative will call and give you full details and advice.

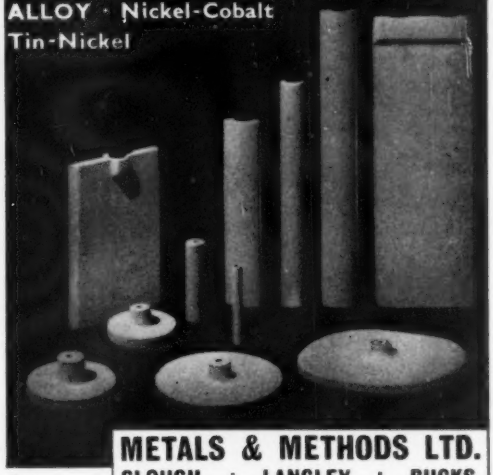
Telephone BLOXWICH 76251

JOHN HAWLEY & CO. (WALSALL) LTD.

GOODALL WORKS BLOXWICH ROAD WALSALL STAFFS

HIGH QUALITY ANODES *for* **ELECTROPLATING**

NICKEL · Depolarized Carbon
ALLOY · Nickel-Cobalt
Tin-Nickel



METALS & METHODS LTD.
SLOUGH · LANGLEY · BUCKS.
Telephone: Langley 555

Sole distributors in the United Kingdom of "High-Speed" Tin Anodes

Hats off to Wellington!

In the finishing shop they're old hands, but none of them remembers a time when they weren't using the coated abrasives with the Wellington trade mark. They're Oakey abrasives — made by perfectionists *for* perfectionists.

COATED ABRASIVE PRODUCTS FOR ALL METAL TRADES

OAKEY

IN BELTS · DISCS · SHEETS & COILS

JOHN OAKEY & SONS LTD.
WELLINGTON MILLS · LONDON · S.E.1

OA1736

increasing use of Gluconates for cleaning, polishing and the removal of rust

Sodium Gluconate, the new sequestrant, is being increasingly used for cleaning metals. When added to caustic soda it makes an efficient de-rusting compound and is effective in cleaning aluminium and aluminium alloy surfaces in etching processes. Gluconic Acid is also an effective metal cleaner, with a low corrosive rate in electro pickling, and has the effect of increasing the brightness of metal deposits during electroplating.

KEMBALL, BISHOP

Chemicals for Industry

The Sales Dept.
KEMBALL, BISHOP AND COMPANY LIMITED
RAMSGATE ROAD - SANDWICH - KENT
Telephones: Advance 1234, Sandwich 2371 } *Private interconnecting lines*

Gluconic Acid 50%

Glucono delta Lactone

Sodium Gluconate

Sodium Potassium Tartrate

Tartaric Acid · Cream of Tartar

All are important as weak acid solutions for cleaning and polishing metal surfaces, especially in the electroplating industry. Sodium Potassium Tartrate is a most useful additive to copperplating baths improving the concentration of copper in solution and giving a finer grained deposit.

DYESTUFFS for COLOUR ANODIZING

Use the ALUMINIUM DYESTUFFS specially manufactured by:—
DURAND & HUGUENIN SA., Basle, Switzerland

- A COMPREHENSIVE RANGE
- STABLE IN SOLUTION
- EASILY AND QUICKLY APPLIED
- EXCELLENT SELECTION NOW AVAILABLE FOR ARCHITECTURAL WORK

ORMINAL

FERRIC AMMONIUM OXALATE IN A NEW POWDER FORM

U.K. enquiries to:—
BARD AND WISHART, PARKSIDE ROAD, SALE, CHESHIRE
Telephone: SALE 4624
STOCKS FOR IMMEDIATE DELIVERY

SEE US ABOUT THE

FIRST

WHEN launching a new product, much time and money is often saved by consulting us at the *early* stages about the requirements of metal finishing.

As pioneers and leaders in this field, our service is backed by the largest anodising plant in the country, and a modern laboratory with qualified chemists to deal with any problems involved.

Our patented processes include an anodising process to produce a hard, wear-resisting, anti-corrosive surface in 14 different colours, chemical and electro-brightening, etc.

SEND FOR BROCHURE

Also Alumilite **HARD** Anodising, a unique finish with exceptional resistance to abrasion, suitable for bearings, pistons, cams, generator brush boxes, and many other applications.

ALUMILITE & ALZAK LTD.

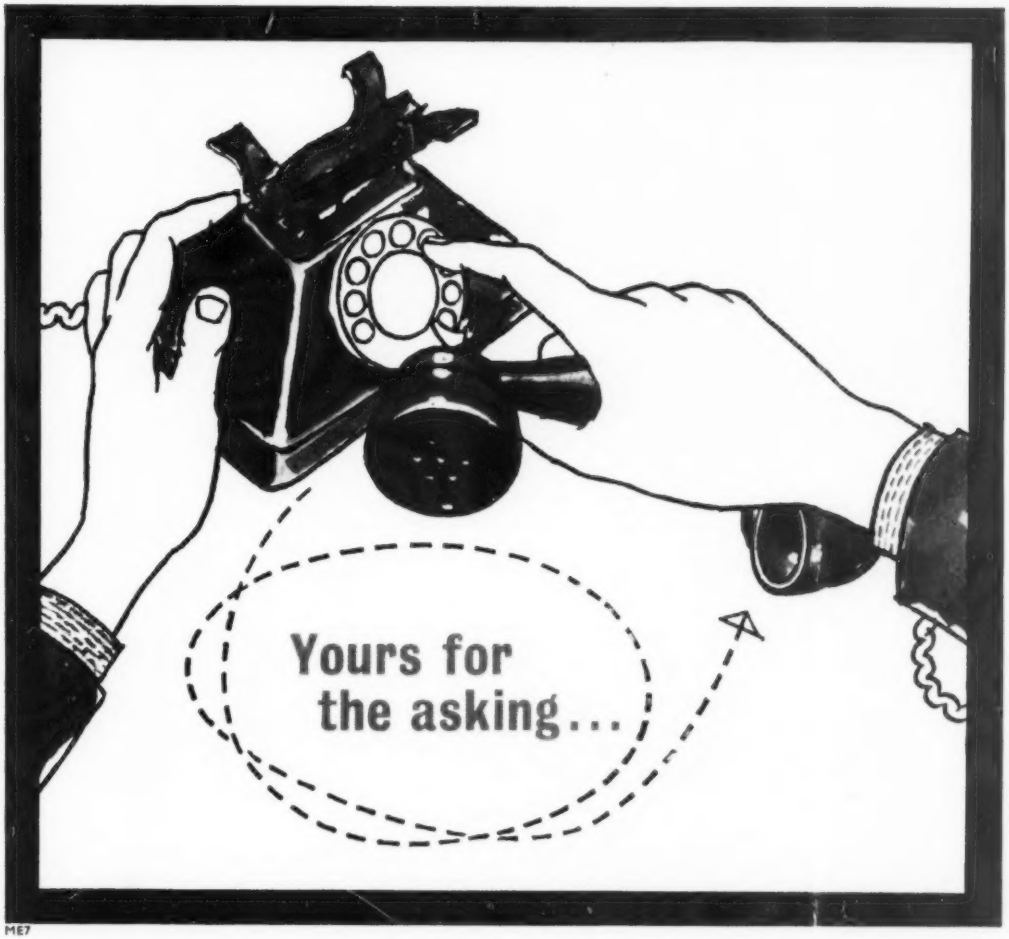
PRIORY WORKS, DEPT. E., STATION ROAD, LONDON, S.W.19. Tel: LIBerty 7641

MIDLANDS: 20/21, MERIDEN STREET, BIRMINGHAM. 5 Tel. MIDLAND 7426

INDEX TO ADVERTISERS

	Page
Aerograph Co. Ltd.	—
Albright & Wilson (Mfg.) Ltd.	22
Alkan. M. L., Ltd.	—
Alumilite & Alzak Ltd.	28
Analytical Measurements Ltd.	—
Anti-Dust Services Ltd.	14
Associated Chemical Companies	—
Atlas Copco (Great Britain) Ltd.	3
Ballard, F. J., & Co. Ltd.	—
Bard & Wishart	27
Berger, Lewis & Co. Ltd.	18
Bilston Shot & Grit Co. Ltd.	—
Blake Vitreous Enamelling Ltd.	—
Blythe Colour Works Ltd.	—
Borax & Chemicals Ltd.	14
Borax Consolidated Ltd.	—
British Chrome & Chemicals Ltd.	6
British Paints Ltd.	11
British Rolling Mills	17
British Titan Products Co. Ltd.	1
Brotherton & Co. Ltd.	—
Canning, W., & Co. Ltd.	4 & 5
C. Christopherson & Co. Ltd.	25
Cruickshank, R., Ltd.	—
Dawson Bros. Ltd.	—
Electro Chemical Engineering Co. Ltd.	7
English Abrasives Corporation Ltd.	—
Escol Products Ltd.	—
Gas Council	—
Glebe Mines Ltd.	—
Glostics Ltd.	9
Griffiths. A. E. (Smethwick), Ltd.	—
G.W.B. Furnaces Ltd.	16
Hawley, John, & Co. (Walsall) Ltd.	26
Hockley Chemical Co. Ltd.	—
Hot Dip Galvanizers Association	—
Imperial Chemical Industries Ltd.	15 & 20
Impregnated Diamond Products Ltd.	9
Incandescent Heat Co. Ltd.	—
Kemball, Bishop & Co., Ltd.	27
King, Geo. W., Ltd.	—
Laporte Chemicals Ltd.	—
Laporte Titanium Ltd.	2
Magnus Chemical Co. Ltd.	25
Main Enamel Manufacturing Co. Ltd.	29
Metals & Methods Ltd.	26
Metropolitan-Vickers Electrical Co. Ltd.	—
Mond Nickel Co. Ltd. (The)	13
Morris, B. O., Ltd.	—
Nash & Thompson Ltd.	—
Newton Plating Jigs & Insulations Ltd.	12
Nu-Way Heating Plants Ltd.	—
Oakey, John & Sons	26
Plastic Fan Co. Ltd.	10
Pyrene Co. Ltd.	—
Richard, Thomas & Baldwins (Sales) Ltd.	—
Silvercrown Ltd.	—
Sismey & Linforth Ltd.	—
Stordy Engineering Ltd.	8
Stuart, Robert, (London), Ltd.	12
Summers, John, & Sons Ltd.	—
T.C. Spray Finishing Systems	—
Volspray Ltd.	24
Wallace & Tiernan Ltd.	—
Walterisation Ltd.	—
Wengers Ltd.	—
Zinc Alloy Rust-Proofing Co. Ltd.	—

Published by the proprietors INDUSTRIAL NEWSPAPERS LTD., John Adam House, 17-19 John Adam Street, Adelphi, London, W.C.2, and printed by F. J. PARSONS LTD., London, Folkestone and Hastings



ME7

If it's anything to do with frits, colouring oxides or vitreous enamelling, we can help.

All our frits are shop-tested within our own organisation; all are proved in production and guarantee a fine finish. We are specialists in the production of dry enamels for bath finishes and can offer a fully acid-resisting and alkali-resisting lead-free enamel of exceptionally high workability. Our specialised knowledge and experience is yours for the asking. May we put both at your service? MEMCOL is our trade name. 'Phone us at EDMONTON 1968 Or write to:

MAIN ENAMEL MANUFACTURING CO. LTD.

GOTHIC WORKS, ANGEL ROAD, LONDON N18

ARTBRITE

STEEL SHEETS

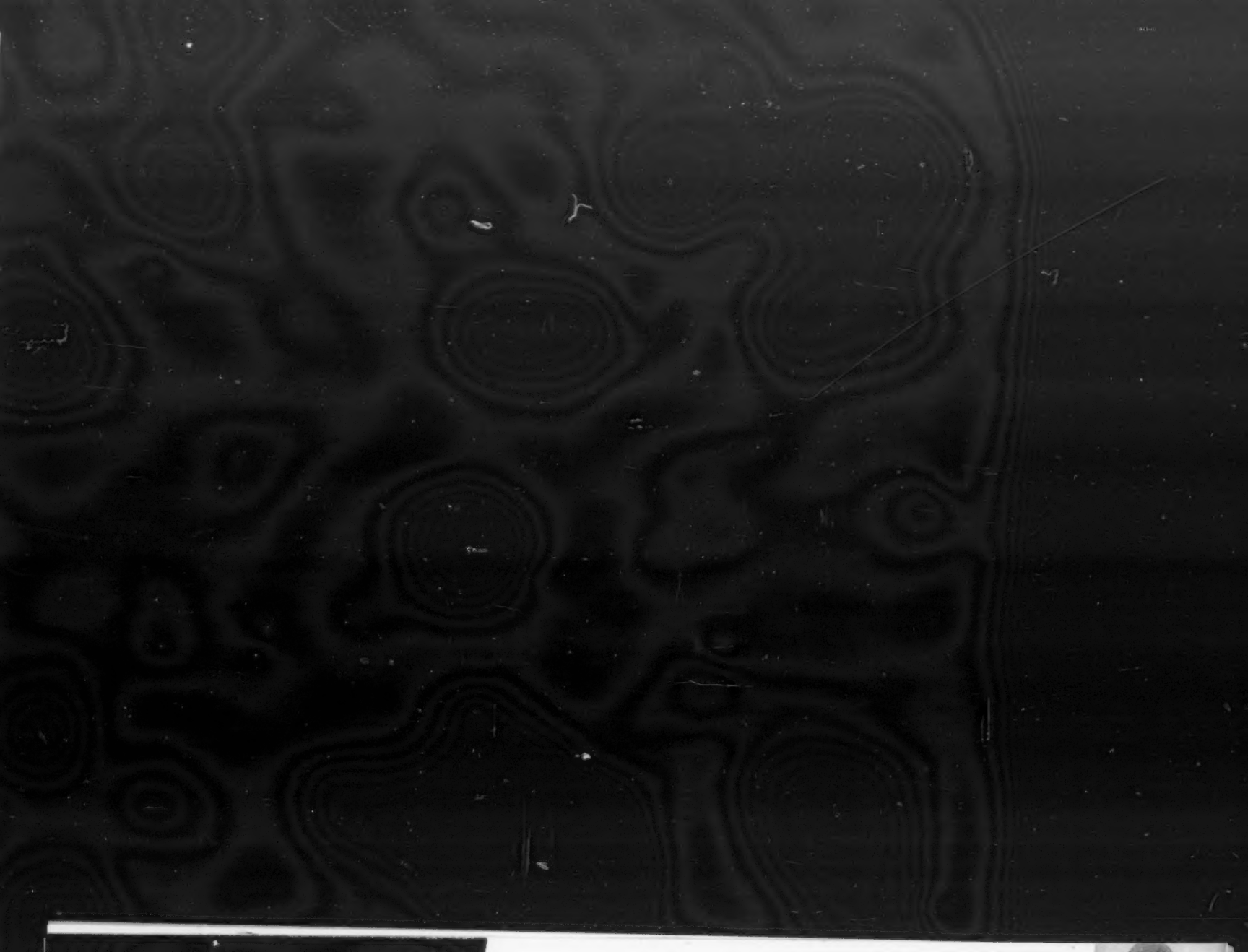
plus COLOUR plus TEXTURE

'Artbrite' sheets are RTB M.S. sheets (protected by hot-dip 'Speltafast' galvanizing or by lacquering) with a closely-adherent 10 thou. coating of P.V.C. film.

Available in many luxury finishes, glossy, matt, and various textures, and in a wide range of colours, the coating is resistant to abrasion and to a great many chemicals. 'Artbrite' sheets on the 'Speltafast' base are fully weather-resistant.

EXTRAORDINARY 'WORKABILITY'. 'Artbrite' sheets can be pressed, drawn, bent, seamed, formed and riveted—even welded, without disturbing the adhesion of the P.V.C. For all intents and purposes, this will stand up to everything that the steel sheets will stand. In sheets up to 48" wide, gauges 16 to 26 b.g. inclusive, at competitive prices.

This cupping test piece shows the elasticity and adhesion of the P.V.C. coating, and retention of the surface texture.

Richard Thomas & Baldwins (Sales) Ltd

47 PARK STREET, LONDON, W.1